DECEMBER 4, 1959

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THE AEROPLANE and ASTRONAUTICS

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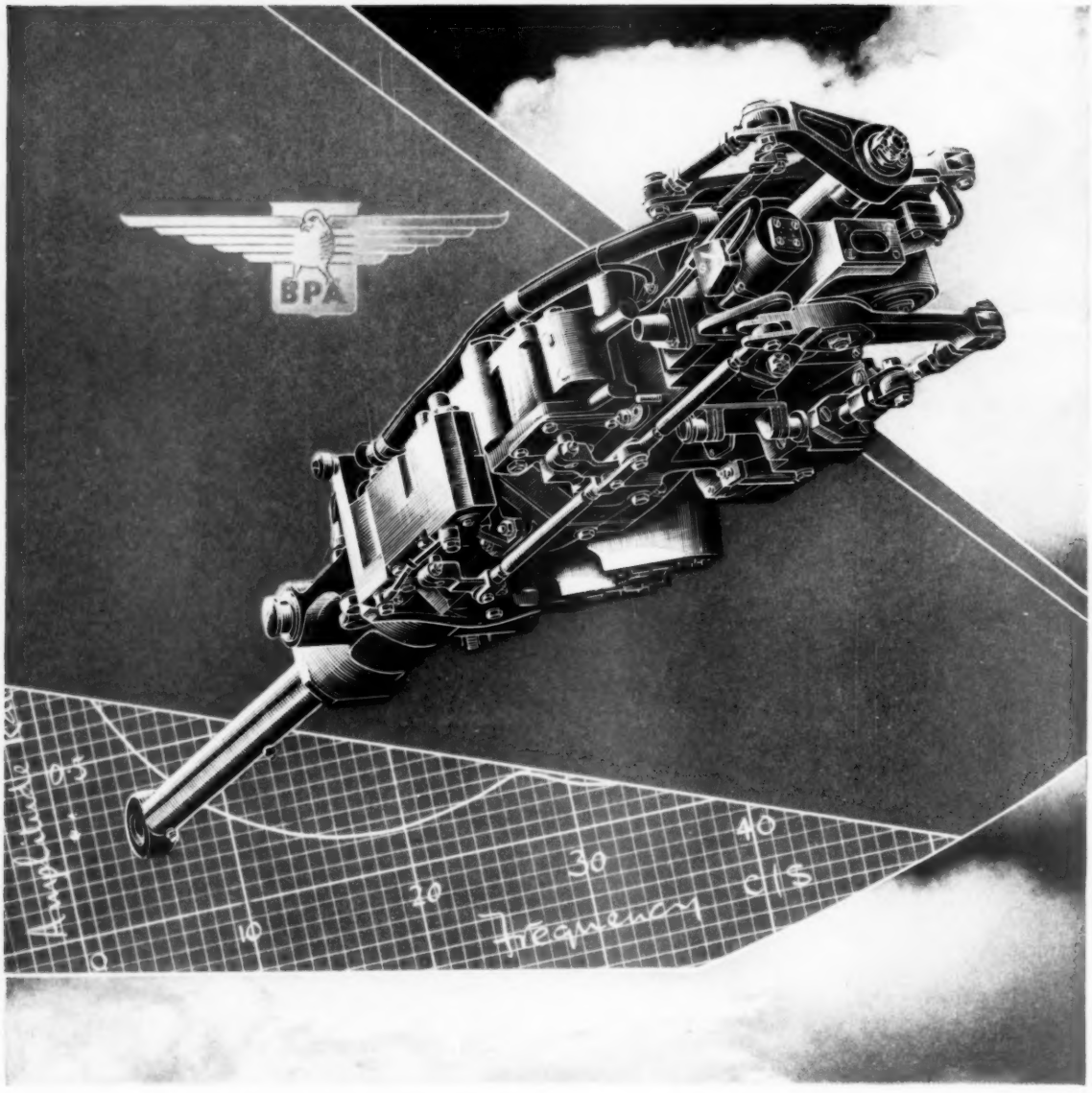

Power Controls

The powered flying control unit illustrated operates the ailerons of the Blackburn NA.39 strike aircraft, in which low-level precision control is an essential requirement. It consists of a tandem ram controlled by rotary valves. Separate hydraulic supplies to the two sides of the ram ensure duplication, and the unit embodies an integral autostabilizer/auto-pilot actuator.

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Northrop's N-156F is the first airplane U.S.-designed specifically for defense needs of other Free World nations. The Freedom Fighter takes advantage of the new General Electric high thrust-to-weight ratio J85 jet engines, new lightweight materials, new design technology that no other fighter yet reflects.

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* short take-off and landing

NOW THE STOL* HERCULES

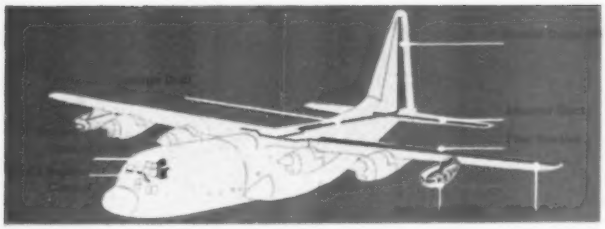
A boundary layer control system, which will spectacularly shorten the already astonishingly brief take-off and landing runs of Lockheed's versatile 67-ton C-130 Hercules transport, is now in an advanced stage of development.

The Lockheed BLC system culminates many years of study by Lockheed engineers and follows four years of research devoted to specific application of the system to the Hercules.

Four auxiliary jet engines, weighing only 500 pounds each, will furnish the streams of high pressure air which flow over wing, empennage and flaps to decrease STOL speed. They can quickly be removed when BLC is not needed.

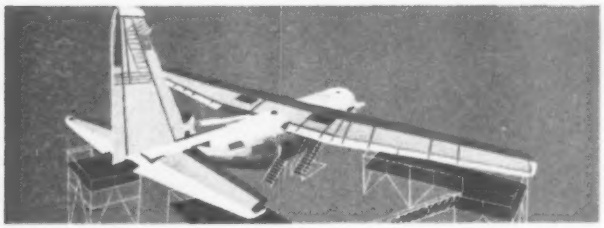
Manufacturing work on the BLC Hercules can begin now because 80% of the airplane is identical to the C-130 B. In Europe, a nation or group of nations could manufacture tne C-130 B and have a European version flying in 1961—less than half the time required by a new untested design. The program could then be phased into the more advanced BLC Hercules. Know-how acquired by Lockheed in manufacturing nearly 300 C-130s to date can make the BLC Hercules European manufacturing project the most rapid and inexpensive answer to the needs of European nations for a high performance, all-purpose transport.

As a combat transport of men and equipment the C-130 showed its superlative value in airlifts to Lebanon and Turkey.



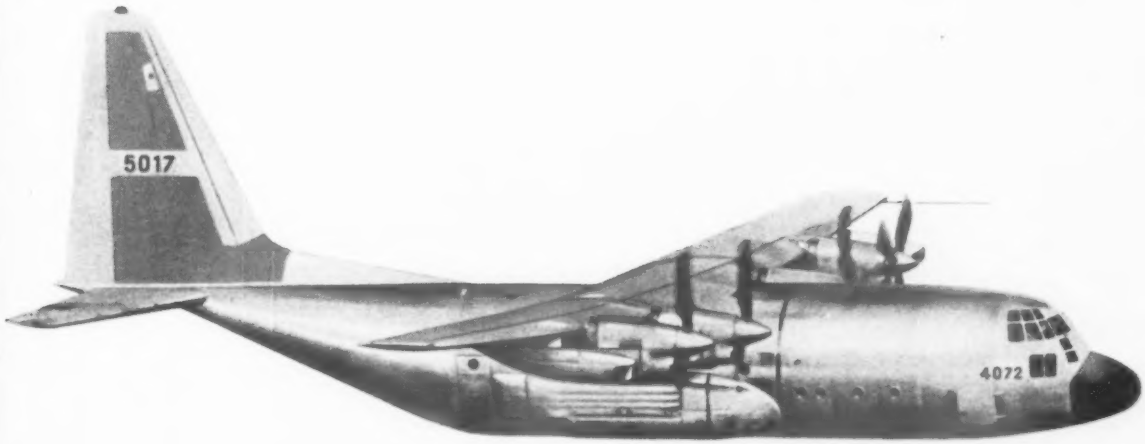
Boundary Layer Control

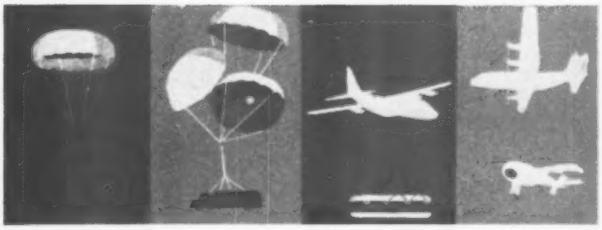
This illustration shows the Boundary Layer Control system of the Hercules. A pod under each wing carrying two small modified jet engines bleeds air which flows over ailerons, flaps, rudder and elevator greatly reducing stall speed of the 67-ton transport.



Licensed manufacture

The Hercules is easily adapted to licensed manufacture. Plans for its production in Europe by a nation or nations cooperating with Lockheed have been carefully studied. Results emphasize spectacular saving of both money and time to countries engaged in such a joint enterprise. The Hercules could be produced in Europe in less than two years.





Versatility

The excellent range capabilities of the C-130 enable it to perform long search and patrol missions. Moreover, it can be easily adapted to many different mission configurations including Paratroop Drop, Aerial Cargo Delivery, Air Rescue, Drone Launcher / Director Aircraft, Troop Carrier, Air Refueling, Aerial Mapping and Surveying, etc.

Soft Field Take-off and Landing

The unique landing gear design of the C-130 permits it to operate from soft, unprepared fields. High gross-weight landings and take-offs have been made on grass, sand and pierced steel plank. The C-130 is the largest aircraft to be equipped with skis for snow and ice landings.

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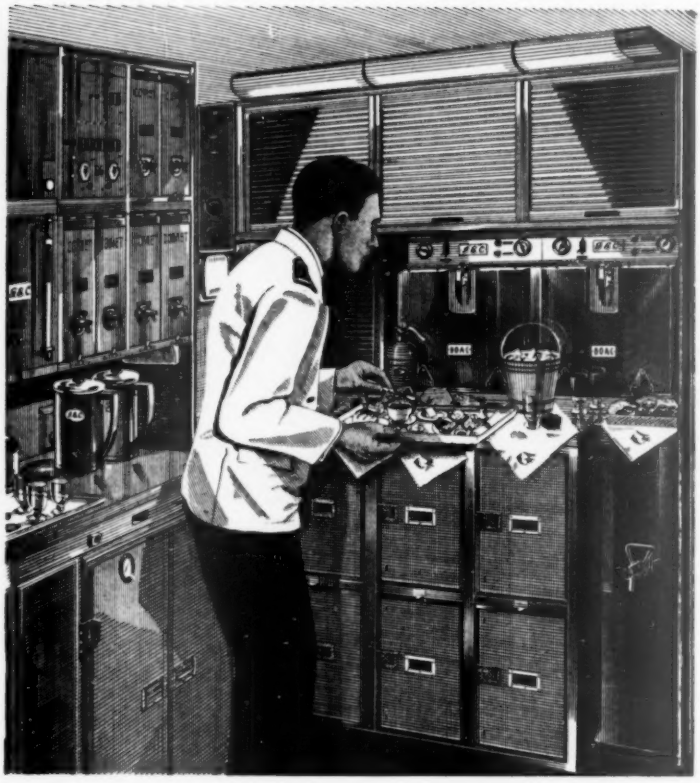

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Pressure Connection: ⅛" B.S.P. Female.
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It can move these men from place to place at a speed of 156 knots. *(289 kph.)*

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•

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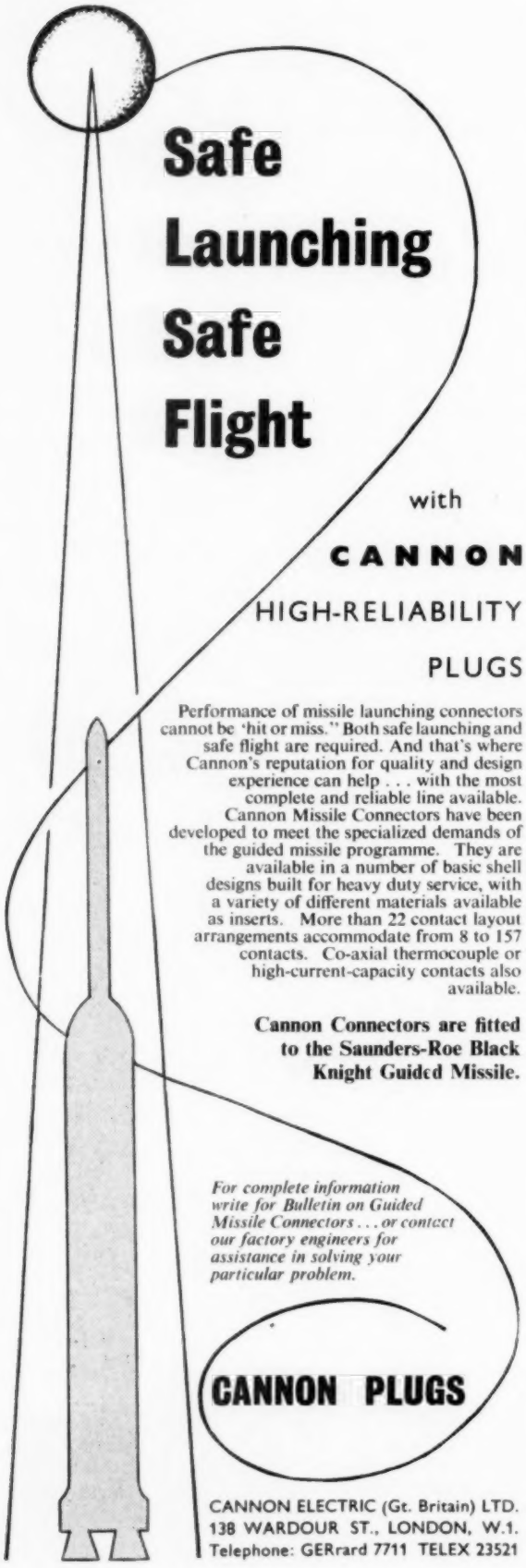

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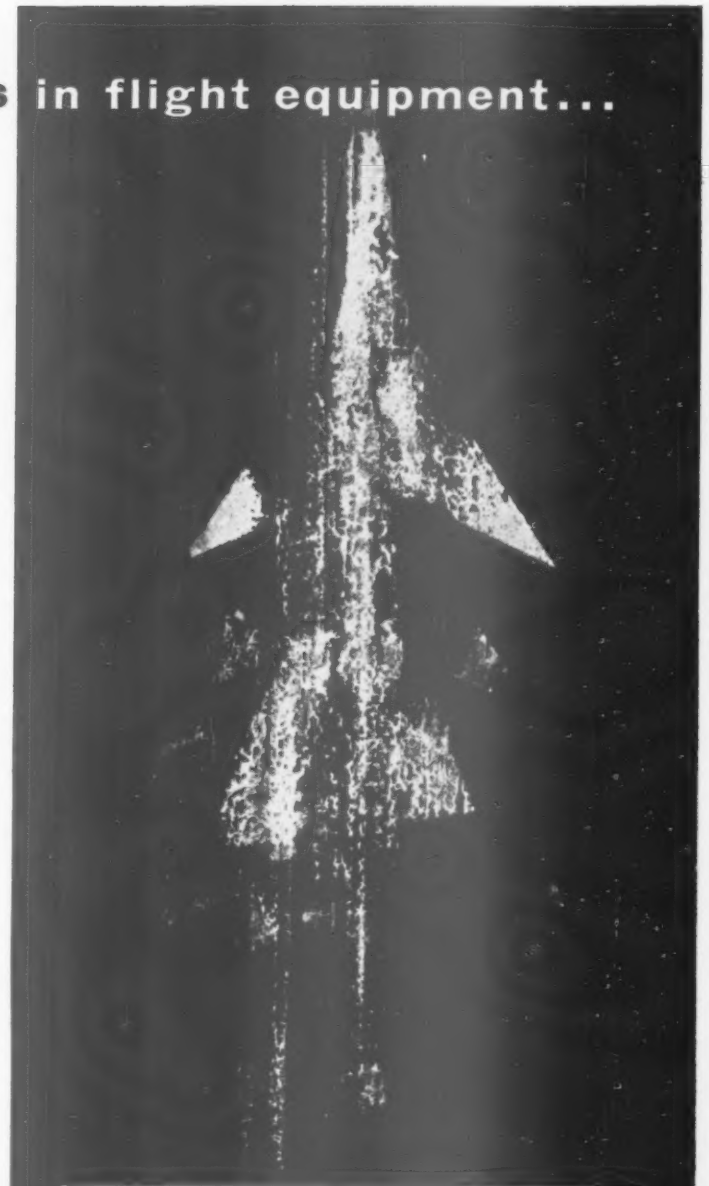

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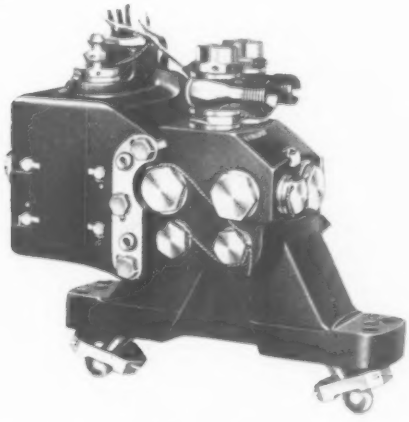

As precision engineers with over 50 years experience in the aircraft industry, H. M. HOBSON, LTD. *are now participating in many important research and development phases of guided missile control, and this announcement of their association with the* BLACK KNIGHT *further exemplifies the Company's aim in keeping pace with progress.*

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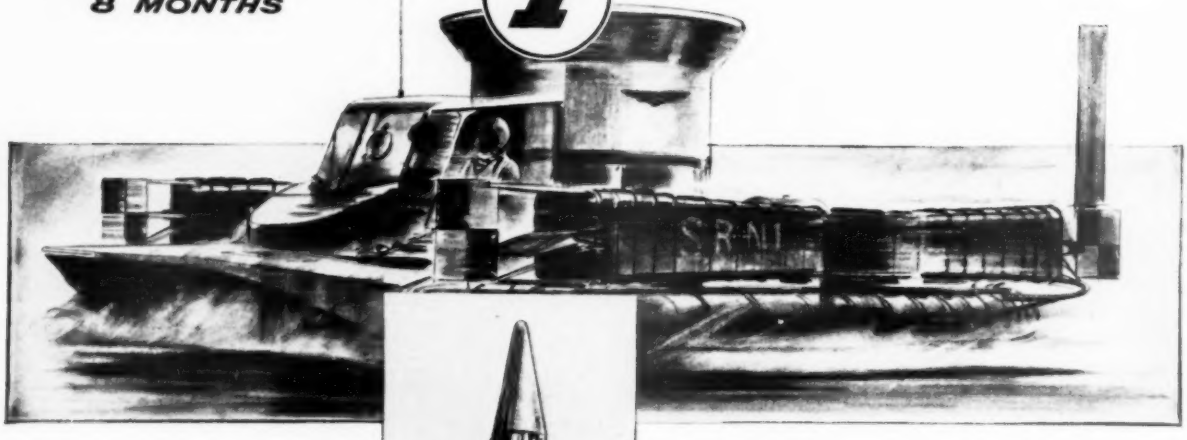

2

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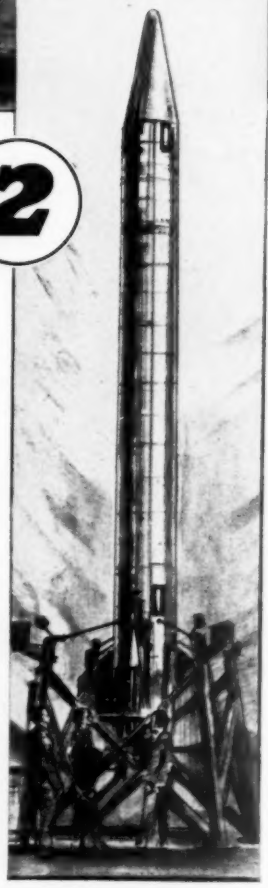

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THE AEROPLANE and ASTRONAUTICS

VOLUME 97 NUMBER 2511 DECEMBER 4, 1959

Light Aeroplanes in the Offing

Private-owner members of the Royal Aero Club, or perhaps we should say enthusiastic members who hope to be private owners, were probably somewhat disconcerted to find that the deliberations of their representatives found their way into the headlines of the Sunday newspapers. Some dozen years ago a committee, known as ILAC (the letters mean Informal Light Aircraft Committee) was brought into being. After much deliberation this body approved various specifications.

One of these, modified to meet present-day conditions, will soon be submitted to the new Minister of Aviation in the hopes that he will be able to get something moving. Mr. Sandys will be better off than his predecessors. Since the end of hostilities the building of British light aeroplanes has been inhibited by the lack of a suitable powerplant. Today plans are well advanced for the building of a well-proven horizontally opposed unit of established performance. The licence for such an engine from its transatlantic producers has, we believe, been acquired by an internationally known aero-engine manufacturer in this country.

This is not only important for the production of the resuscitated ILAC aeroplane, but as a necessary complementary activity to the plans of two large aircraft manufacturers in this country, one of whom has decided to go ahead with a series of light aeroplanes for the executive market and the other with a lightweight freight-carrier. Both plan to rely on the new engines.

But new aeroplanes will not be enough. There has been much discussion in our pages about the danger of collision in the air. We have been consistently arguing the need for all light aeroplanes to carry radio. None of us in aviation can be happy till they do.

Minors for Major Muscle Prize

If present opinions have their way, Mr. Henry Kremer's £5,000 prize is not going to fall to the first contender. In a recent editorial we suggested, bearing in mind Lord Brabazon's historical precedent, that the prize should be awarded to the first to complete a circular mile by muscle power alone. This suggestion was taken up by Mr. Peter Masefield, president of the Royal Aeronautical Society, at the inaugural MAPAG meeting. However, those charged with working out the rules have come to the conclusion that a figure-of-eight course around markers 880 yards apart would be an effective way of demonstrating ability to fly and to control the aircraft. Likely contenders will be glad to know that they look like being able to count on using "ground effect," as the average height to be maintained is 10 ft.

The winner might well be a very minor minor. Our gliding correspondent in reporting Dr. Wilkie's recent lecture on manpower in terms of horse-power has concluded that an intelligent schoolboy might have the best chance. Mr. Dan Perkins had better look out. A 12-year-old schoolboy weighing 6 stone might well be carried by an aircraft weighing much less than 74 lb. And if the MAPAG debaters are right, the same schoolboy might have enough horse-power to get such a featherweight off the ground.

Editor - - - - THURSTAN JAMES
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Telephone: TERminus 3636
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Annual Subscription Rate: United Kingdom £4 15 0
Overseas £5. Canada and U.S.A. $15.00

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Matters of Moment

Bloodhounds for Australia

A DECISION to order the Bristol/Ferranti Bloodhound surface-to-air defence system was announced by the Australian Minister of Defence on November 26. This news is particularly welcome because recently Australia has shown a tendency to order U.S. military equipment and the Nike SAM was a rival for this order. Australia has been in a very good position to assess Bloodhound's potentialities because the missile is tested at Woomera.

It has not been revealed whether Australia has ordered the initial version of Bloodhound or a later one. Doubtless the development potential of this missile and the extended range promised by later versions must have influenced the decision.

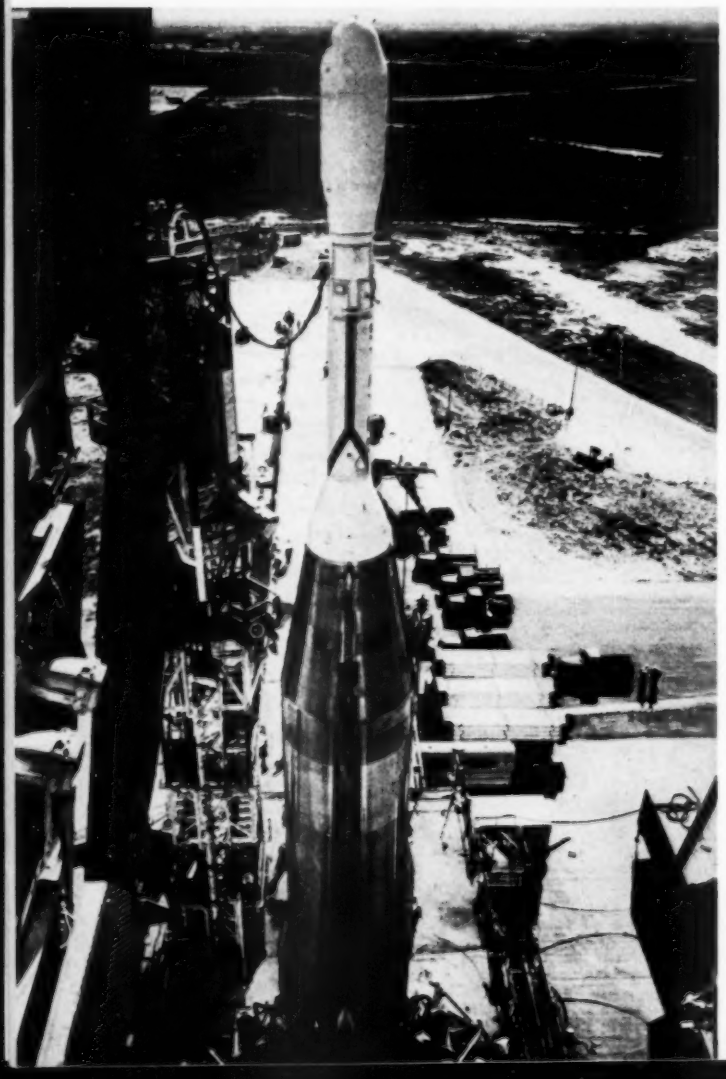
Three countries will now be defended by Bloodhounds—Britain, Sweden and Australia.

Help Towards B.E.A.'s Helicopters

IN the news last week was a contribution by the Ministry of Aviation of £1,400,000 to B.E.A. as a measure of help towards the introduction of helicopters into the Corporation's services. This financial support will assist in covering the development costs involved in B.E.A.'s plans to put Fairey Rotodynes into service in 1963-64 on some domestic routes and on the shorter Continental routes. It is, however, intended to cover such things as ground equipment and special installations and will in no way go towards the development of the aircraft itself.

As we reported last week, a Government contribution in the form of a development contract worth £4 million is the subject of current negotiations and within a few weeks of signature. The company's chairman, Mr. Geoffrey Hall, has made it clear, however, that although B.E.A. has given a Letter of Intent for six Rotodynes there is, as yet, no firm order for the aircraft. Indeed, he also said in his annual chairman's report that in the prevailing circumstances it was difficult to decide whether to persist with a project as large without a clear and sufficiently large Government order.

JET CEREMONIAL.—Sir Frank Whittle watches the naming of a T.W.A. Boeing 707 before its inaugural London-New York flight on November 24 by Janette Scott. Mr. C. S. Thomas, T.W.A. president, helps.



International Operators Look Ahead

FOR the 13th time members and guests of the Foreign Airlines Association have lunched together in London. On November 27 last the guests were received by the chairman, Mr. W. H. Whelan (Aer Lingus), and the honorary treasurer, Mr. M. A. S. Dalal (Air India International).

MR. W. H. LYONS (Pan American World Airways), in proposing the toast of "British Civil Aviation" and noting that P.A.A. were celebrating the completion of their first year of jet operation, paid a tribute to the British who had showed the way. In the most courteous way he reminded the Government (in the person of Mr. Rippon) of the rather less than ideal conditions at L.A.P. North, schemes of amelioration seemed to be stretching rather hazily into the future. Jet operators, he said, regarded the rising cost of operation with concern, not least in the field of facilities. Here the imposition of British services charges might be regarded by passengers as a retrograde step. The appointment of Mr. Sandys as Minister of Aviation showed the importance the Government paid to the subject of civil aviation. They would all look forward keenly to learning of what was planned for the days ahead.

MR. GEOFFREY RIPPON referred to the appointment of Sir Frederick Brundrett to be chairman of the Air Traffic Control Board. The creation of this reconstituted body by the Ministry of Aviation was a proof of the awareness of the Government of how aviation increased trade and enlarged friendships. As regards the change-over from L.A.P. B.O.A.C. should complete its move by the latter part of 1961. It was hoped to complete the new long-haul building some time in 1962. It was important not to move too quickly as there was danger of planning on inadequate figures.

His excellency the Swedish Ambassador, MONS. GUNNAR HAGGLOF, G.C.V.O., replied to the toast of the guests proposed by Mr. J. SIGURDSSON (Icelandair).

Lanchester Memorial Lecture

PROF. DR. H. SCHLICHTING, the first German to lecture before the Royal Aeronautical Society for 20 years, gave the third Lanchester Memorial Lecture on November 26. Its title was "Some Developments in Boundary Layer Research in the Last Thirty Years." Prof. Schlichting, who spent two years after the War at the R.A.E., Farnborough, delivered his lecture in clear and fluent English.

As the lecture indicated, developments have been based on the pioneer work of Prof. Prandtl and his associates at Göttingen. Highlights of the work at Göttingen were the theory of transition established by Tollmien in 1930 and the construction in 1938 of two aircraft using boundary-layer

MOON PROBE.—On the launching pad at Cape Canaveral, Atlas-Able is prepared for the abortive attempt to send a probe into orbit around the Moon. (See p. 566.)

WINGED MIL.—The Soviet Mi-6 set up a new 100-km. closed-circuit record on November 21, with a flight from Tushino, via Istra and Galitzina, at 167.206 m.p.h. Its wing provides some 20% of the total lift in cruising flight.

suction for high lift. In tests with these aircraft, lift coefficients up to 4.0 were achieved. Other work included comparative wind-tunnel tests of straight and swept wings at Mach 0.7 and 0.9. These tests had been made in 1938.

Prof. Schlichting remarked that the output of papers on the boundary layer had increased almost exponentially. In the first decade of this work they had been published at the rate of less than one a year; between 1924 and 1934 the rate was about five or six a year and between 1944 and 1954 it reached 120 papers a year.

Sir Roy Dobson on Space Flight

AT a private dinner party given by the Council of the British Interplanetary Society at St. Ermins Hotel on November 26, Sir Roy Dobson, C.B.E., Hon. F.R.Ae.S., J.P., managing director of the Hawker Siddeley Group, received the appreciation of the Society for the considerable assistance which Group companies gave at the time of the Commonwealth Spaceflight Symposium and the 10th I.A.F. Congress. In recognition of this support and interest, Dr. L. R. Shepherd, chairman of the B.I.S., presented Sir Roy with a painting by John W. Wood depicting the Armstrong Whitworth "pyramid" re-entry vehicle as it would appear on the three-stage launching vehicle. The "pyramid" vehicle was the subject of a paper by Mr. H. R. Watson, technical director of A.W.A., given at the Symposium last August.

In a short speech following the presentation, Sir Roy Dobson said that, in his opinion, a major function of the B.I.S. should now be to convince Government and Industry of the practical aims of space research and development. "Having convinced yourselves of the importance of space flight," he said, "you have now to convince others."

Muscles for Human Flight

JUST why a man can produce several horse-power in a spurt for only a very short time, yet keep up a steady 0.5 h.p. indefinitely, was explained by Dr. D. R. Wilkie, of University College, at the second lecture meeting of the R.Ae.S. Man-powered Aircraft Group on November 27. It is a question of chemistry.

In the steady state, the glucose fuel is completely oxidized to carbon dioxide and water, which are no hindrance to further effort. But in a spurt, oxygen cannot get to the muscles fast enough, so the process is not oxidation but hydrolysis, leading to an accumulation of lactic acid which soon brings the process to a halt. Recovery from this state needs oxygen, and cannot take place while all the oxygen brought to the site is being used to keep the "steady state" power output going.

Another difference, Dr. Wilkie said, is that heat accumulates more quickly during hydrolysis, whereas with oxidation (in the steady state) the heat problem only gets severe after five minutes.

For the initial spurt, theory shows that all a man's muscles together could produce 12 h.p. However, about half his muscles act antagonistically to the other half, so that theoretical useful maximum is 6 h.p.—not much more than the 5 h.p. which an athlete can produce during the first half-second when accelerating from rest.

But in the steady state Dr. Wilkie doubted whether it would give any advantage to use both arm and leg muscles, as the second occupant of the proposed machine is expected to do, because in this state the maximum amount of muscle in use is limited by the man's possible oxygen intake. In fact, the late Oskar Ursinus, who tried out many alternative ways of getting power out of human muscles, found it impossible to improve on the ordinary pedal cycle, using the legs only.

After discussing one member's revelation that, in cycle racing, small size is known to give an advantage, the meeting concluded that man-powered flying might be most efficiently done by a boy of the smallest possible size consistent with enough intelligence for the job.—A.E.S.

M.o.A. Establishments

WITH the recent amalgamation of the Ministry of Supply and the Ministry of Transport and Civil Aviation to form a single Ministry of Aviation, a number of research and experimental establishments have been transferred to the new organization while others have been taken over by the appropriate Service departments. In a reply to a question in the House of Commons last week, Mr. Duncan Sandys, the Minister of Aviation, gave a list of those that are now under his control. These are:—

Royal Ordnance Factory, Burghfield; Royal Ordnance Factory, Cardiff; Royal Aircraft Establishment, Farnborough, and its outstations; Royal Radar Establishment, Malvern and Pershore; Aeroplane and Armament Experimental Establishment, Boscombe Down; Tropical Experimental Unit, Idris, Libya; Aircraft Torpedo Development Unit, Helston; National Gas Turbine Establishment, Pyestock; Empire Test Pilots'

PIONEERS TOGETHER.—Lord Brabazon (right), president of the Royal Aero Club, paid an eloquent tribute to Sir Frederick Handley Page (left) at a dinner of members at 119 Piccadilly, London, W.1, on November 24. The gathering was in recognition of Sir Frederick's fifty years' continuous connection with aviation and his association with the Royal Aero Club since 1911. A bronze bust of Sir Frederick was accepted on behalf of the Club.

Matters of Moment . . . .

School, Farnborough; Rocket Propulsion Establishment, Westcott; Signals Research and Development Establishment, Christchurch; Explosives Research and Development Establishment, Waltham Abbey and Woolwich.

One former M.o.S. Establishment that has been lost to the M.o.A. is A.R.D.E. (the Armament Research and Development Establishment) at Fort Halstead. Although this does a good deal of work for the R.A.F. and is closely associated with certain missile work (THE AEROPLANE AND ASTRONAUTICS for November 13) it is rather more concerned with general ordnance work and is, therefore, now a War Office Establishment.

Altogether, 42,000 former M.o.S. employees are now under the jurisdiction of the War Office. Of these, 30,000 are industrial employees in the Royal Ordnance Factories and research and development establishments.

Aircraft to Motorcars

ANOTHER move from the aircraft industry to the motor industry is taking place. As from December 24 next Mr. W. F. F. Martin-Hurst, who has been managing director of Teddington Aircraft Controls, Ltd., since 1946, is joining the Rover Co., Ltd.

The new managing director of Teddington Aircraft Controls, Ltd., is well known in the aircraft industry. He is Mr. C. S. Gardner, at present works director, who has been an executive director of the company since 1945.

C. T. R. Wilson

PROFESSOR C. T. R. WILSON, F.R.S., who has just died at the age of 90 after achieving World fame as a physicist, might not have reached one-third of that age but for his quick grasp of physical principles. As a young man he was watching a thunderstorm from the summit of a Scottish mountain when he felt his hair standing on end, so he scampered down off the summit just before a lightning flash struck.

This started a train of thought which led to his theory of thunderstorm electricity. According to this a raindrop collects negative ions as it falls, because its positive pole is on its underside due to the electric field, but it drops so fast that positive ions cannot get round to its negative upper side; consequently, falling rain collects a negative charge and carries it down.

What an interest in the clouds can lead to was shown after he had volunteered to do holiday duty at the observatory on the top of Ben Nevis. He noticed his "Brocken Spectre" shadow on the clouds below and decided to try to produce it artificially in the laboratory.

This series of experiments led to his famous "Wilson Cloud Chamber," in which he proved that cloud droplets could condense not only on to dust nuclei, but on to ions, which he produced in his cloud chamber with the newly discovered X-rays in 1896. The same apparatus led later to fundamental discoveries, such as the properties of neutrons and mesons.

At the age of 86, Wilson suddenly took to flying over his beloved Scottish mountains and the Western Isles, in aeroplanes provided for students of the meteorology class in Edinburgh University.—A.E.S.

Antipodean Wroundabout—Homeward the Herald

Papua and New Guinea.

This Herald, now pointed towards home, just keeps on and on. I use it like a bus, darting from place to place. It never falters. What a pity New Zealand National Airways Corporation didn't change their mind and order it. While understanding their reasons, when their Friendship decision was announced, I sympathized with the patriot who reckoned that N.A.C. meant "Not A Clue."

During Australian diversions in Viscount, Electra and DC-4, I've questioned fellow-passengers. All who have flown high-wing prefer it, not only for the fine view, but also because "you can't see the flamin' wing bending." One man's vote: "The Electra's not for me—it doesn't give you time to enjoy your sherbet and your meal." Now they're complaining about going too *fast!*

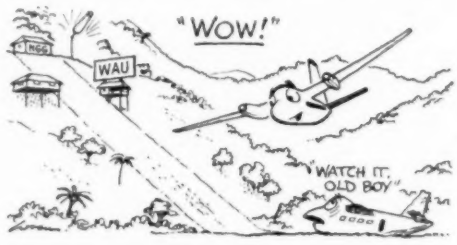
And so to Woomera again after a seven-year interval. Then: Ground equipment, burnt patches in the desert, and kangaroos. Now: More ground equipment, lots of airborne hardware (I saw a complete Canberra-Firestreak-Jindivik operation and a Thunderbird-Jindivik firing in one day)—and kangaroos.

Extract from an M.o.S. memo to M.o.S. rep. in Melbourne: "An R.A.E. representative will accompany each Black Knight that is fired. . . ."

Herald crew talk before Townsville-Port Moresby flight: Rex Shilton, Britavia pilot and navigator: "I've worked out the mileage to be shorter than I know it to be." Alan Johnson, B.O.A.C. pilot: "That's all right—it's the dry season here." Shrivels the distance a bit, I suppose.

In New Guinea's heat, fans hang from every ceiling, blowing down blessed coolness, but disturbing lightweight items, such as paper used for writing columns on, when the paper is not stuck to one's hands. It's rather like trying to work in an open-topped, red-hot helicopter flying through a shower. No, I am not a fan fan.

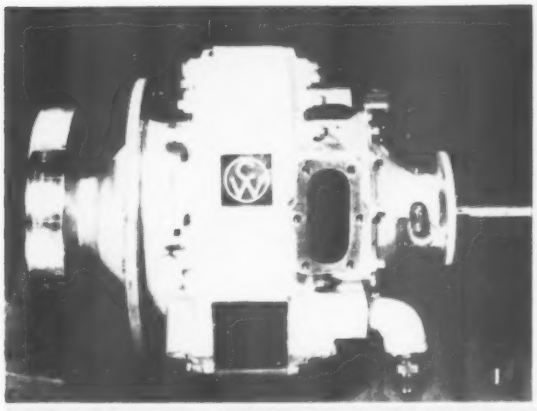
I don't think I told you that the only way Handley Page's could insure against a New Zealander walking into a Dart's propeller was to classify the Herald as "an agricultural machine with an unguarded fan." The top-dressing version of the Herald, of course.

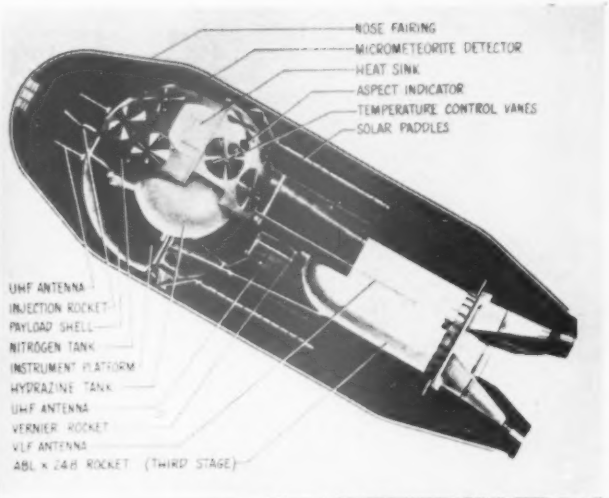


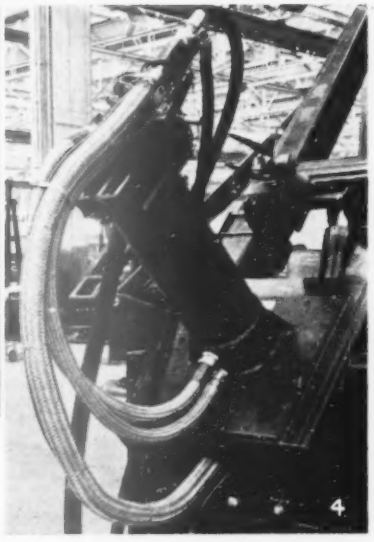
Today, I flew into and out of the famous, or notorious, Wau strip where, confident that no aircraft will ever get that far up the hill to overshoot, New Guinea Goldfields have put their warehouse at the top end, 390 ft. higher than the bottom end. At the bottom lies the battered fuselage of a Bristol Freighter, now used as a "boy house"—native quarters, that is. This is the one which 10 years ago the pilot parked at the top of the strip. The brakes eased themselves off and, ever since, pilots have always parked sideways on the hill and don't switch off until the chocks are under the wheels.

by Lorenz

General Aviation News







(1) This internal-combustion rotary engine developed in Germany has a three-sided eccentric rotor in a four-sided chamber; Curtiss-Wright is developing these engines for aeronautical use. (2) Details of the Atlas-Able payload (see page 566). (3) Two squadrons of F-105 Thunderchiefs are now in U.S.A.F. service; these are from the 334th Tactical Fighter Squadron. (4) Dunlop and Avica flexible hose is used in the Bristol/Ferranti Bloodhound installation—an Australian order for which is recorded on page 554.

ORPHEUS ORDER.—A substantial number of Bristol Siddeley Orpheus 805 turbojets has been ordered by the Japanese Defence Agency for Fuji T1F-2 trainers.

NEW FRENCH CARRIER.—Laid down in 1955 and launched nearly two years ago, the new French aircraft carrier "Clemenceau" has started her first sea trials. Due to enter into active service in 18 months' time, the 22,000-ton carrier has an angled flight deck and steam catapults.

HELP FOR PRIVATE FLYERS.—The A.B.A.C. has arranged with United Dominions Trust, Ltd., for deferred payment facilities to be made available for flying training at A.B.A.C. Member Clubs offering M.o.A.-approved P.P.L. courses. These facilities also extend to refresher and advanced courses up to a maximum cost of £200, with payments spread over 18 months.

TIGER CLUB DOINGS.—At the Tiger Club annual dinner in London last week, chairman Norman Jones announced that the A.R.B. had approved the installation of additional ailerons on the upper mainplanes of Tiger Moth G-AOAA, which was being modified for the next Lockheed Aerobatic Competition. He presented the D.H. Tiger Moth trophy to Miss Janet Ferguson, who flew a Turbulent in the *Daily Mail* Arch to Arc race.

INFLATION.—The 100-ft. "inflatable satellite" recently test-launched from Wallops Island, Virginia, by means of a two-stage rocket was inflated by the action of water boiling off into steam under low pressure at the ejection height of about 220 miles.

EXPORTS.—The British aircraft industry's exports for the first ten months of 1959 were £134,066,669, a 9% increase over the 1958 figures.

DUTCH REPLACEMENT.—The Dutch Defence Minister, Dr. S. H. Visser, is reported to have stated that Holland and Belgium will choose between the Lockheed F-104 Starfighter and the Dassault Mirage 3 as the replacement fighter for their Hawker Hunters.

AUSTRALIAN F.A.A.—The Australian Government has decided to disband the R.A.N. Fleet Air Arm after 1963. At this date the existing aircraft operating from the Australian carrier "Melbourne" will be obsolete, and to replace them would require a new larger carrier.

ABLATION HEAD.—An ablative-type nose-cone is being developed for the Titan ICBM by the AVCO Research and Advanced Development Division to permit faster re-entry speed and improved accuracy. The company has already produced a blunt heat-sink-type nose-cone and re-entry body.

X-18 FLIGHT.—The 16½-ton Hiller X-18 tilt wing VTOL transport, made its first flight as a conventional aeroplane on November 24.

FOR CHRISTMAS

A subscription to THE AEROPLANE AND ASTRONAUTICS for the coming year will make an enjoyable Christmas gift. A twelve-month subscription costs only £4 15s. 0d. (six months £2 7s. 6d.) and the recipient will be sent a greetings card explaining that he will receive THE AEROPLANE AND ASTRONAUTICS regularly by post.

Orders should be addressed to: The Subscription Department, THE AEROPLANE AND ASTRONAUTICS, Temple Press Limited, Bowling Green Lane, London, E.C.1.

Commercial Aviation Affairs

ONE-MAN TRANSPORT.—The Bensen Little Zipster single-seater powered by a 70 h.p. Mercury engine is reported to cruise at 60 m.p.h.

C.P.A. TO ROME.—An agreement has now been signed which will permit Canadian Pacific Airlines to operate, as from March 1, 1960, a twice-weekly service, with Britannia 314/324s, from Montreal to Rome via Lisbon, which is already served.

ELIZABETHANS FOR DAN-AIR.—The three Airspeed/D.H. Elizabethans which were originally bought by Butler Air Transport before the Ansett take-over have now been sold to Dan-Air Services. These Elizabethans, which were flown back to this country some time ago, will be modified by Marshalls of Cambridge before being used for scheduled services (for which Dan-Air have applied) and charter work. The sale was completed by W. S. Shackleton. Three other Elizabethans are in operation with B.K.S. Air Transport, so six of these aircraft will, in due course, be flying with the independents.

AUTOMATION.—American Airlines is to introduce a much-developed reservation computer system in 1961-62. The system, known as SABRE (or I.B.M.9090), will, with its centre in New York, be able to handle more than 7,500 complete reservations per hour. A prototype of the system was demonstrated early last month.

COMET REVERSERS.—Five of B.O.A.C.'s 19 Comet 4s had, by the middle of last month, been fitted with thrust reversers.

ATLANTIC CO-OPERATION.—Trans-Canada Air Lines and B.O.A.C. have agreed to co-ordinate their passenger and cargo schedules between Canada and the U.K. and to arrange for the interchangeability of tickets as from March 1, 1960. (See our issue of September 18, p. 206.)

A.A. MANAGEMENT CHANGES.—Alterations in the H.Q. management structure have been made by American Airlines. Mr. G. Marion Sadler (previously v.-p. sales services) has been appointed to a new position, that of vice-president and general manager. He and five other principal executives will report directly to the president, Mr. C. R. Smith.

THIRD FOR ANSETT.—A third Electra, to be delivered next year, has been ordered by Ansett/A.N.A. 170 Electras have now been ordered and 100 delivered.

SOUTH ATLANTIC PROMISE.—Following a meeting in Paris the South Atlantic operators have now agreed to discontinue the practice of fare-undercutting, by means of heavy discounts, which has been going on for some years.

CAMBRIAN REDUCTIONS.—From April 1, 1960, Cambrian Airways will reduce fares on the Paris, Dinard and Channel Islands services.

CARIBBEAN COMETS.—From February B.O.A.C. will be using Comet 4s on services to Nassau (Bahamas) and Montego Bay (Jamaica) via New York. Three flights per week will be direct from New York to Montego Bay. At the same time the Corporation will introduce three additional North Atlantic Comet return flights weekly with first and economy class accommodation.

KARACHI EXTENSION.—Work has started on a 12,000-ft. runway at Karachi Airport. The cost is being paid by the U.S. Development Loan Fund and the work is being supervised by U.S. Army engineers. This and other improvement plans for the airport are due to be completed by mid-1961.

CHICAGO CRASH.—On November 24 a T.W.A. Constellation freighter hit a row of houses whilst making an emergency return to land after take-off from Chicago's Midway Airport. The crew of three and seven persons in the houses were killed.

News About People

B.O.A.C. APPOINTMENTS.—Capt. R. C. Alabaster has been appointed Comet Flight Manager and Capt. J. A. Kelly as deputy manager. These appointments follow the return to line duties, at their own request, of Capts. R. E. Millichap and E. J. N. Hengle, who previously held these posts.

MALLINSON APPOINTMENT.—Mr. J. P. White has been appointed manager of the aircraft division of William Mallinson and Sons, Ltd., at Thames Road, Crayford, Kent.

Air Cdre. P. G. Wykeham, D.S.O., O.B.E., D.F.C., A.F.C., who becomes A.O.C. No. 38 Group, R.A.F. Transport Command with the acting rank of Air Vice-Marshal, on January 1, 1960.

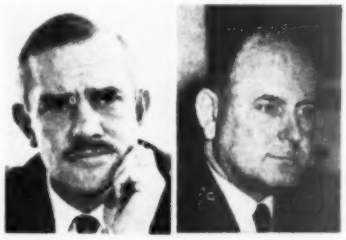
M.o.A. APPOINTMENTS.—Dr. C. M. Johnson, C.B.E., has been appointed director of the Explosives Research and Development Establishment at Waltham Abbey; since 1954 he has been director of the materials and explosives research and development branch at E.R.D.E. Mr. W. H. Hill has been appointed Deputy Director of Air Armament Research; since 1954 he has been at the Armament Research and Development Establishment as superintendent of the weapons assessment department.

AVRO ADDITION.—Mr. Colin Allen has joined A. V. Roe and Co., Ltd., as a test pilot, having spent six years on production and experimental test flying with Vickers Armstrongs on Valiants and Viscounts. He joined the R.A.F. in 1943, finally serving in No. 540 Squadron, flying Mosquitos.

PLESSEY APPOINTMENT.—Dr. D. W. Davidson has been transferred to the central personnel executive staff at the head office of the Plessey Co., Ltd., Ilford. He will be assisting the personnel director with scientific and technical appointments throughout the company and its associates.

GHANA IN LONDON.—Mr. A. H. Bates has been appointed by Ghana Airways as London representative. He has been seconded from B.O.A.C. and has recently been superintendent, stations and traffic, Aden Airways.

JOINING A.W.A.—Mr. J. R. Anderson, formerly of the R.A.E., Bedford, has now taken up the appointment as chief superintendent of wind tunnels at Sir W. G. Armstrong Whitworth Aircraft, Ltd., Coventry. He succeeds Dr. W. F. Hilton who recently transferred to the Hawker Siddeley Aviation Advanced Projects Group at Kingston.



Mr. J. R. Anderson (left) and Mr. J. E. Armitage.

VICKERS CHANGE.—Mr. J. E. Armitage has been appointed commercial director of Vickers-Armstrongs (Aircraft), Ltd., in succession to Mr. J. Anderson, who has retired because of continued ill-health. Before joining Weybridge works as chief accountant in 1947, Mr. Armitage held a similar appointment at the Blackpool factory; he was appointed commercial manager in 1954, and a special director in 1956.

Air Transport

Wakening Jolts for IATA

THE fare-cutting on the South Atlantic and the failure of the traffic conferences to reach agreement in Honolulu have both tended to give the general public the impression that the authority of the International Air Transport Association is less than it should be within the airline industry. But certain apparently minor recent events of a domestic nature, and not generally known, are, in fact, much more important signs of a weakness which is worrying the firmer adherents of this industry association.

On November 11, a correspondent writes, an IATA Breaches Commission wound up nearly three days of hearings at Overseas League headquarters in London. In many ways this was a routine commission of inquiry—of which there are two or three each year, held in London, Paris or New York—examining allegations by the IATA Enforcement Office of violations of Traffic Conference resolutions. Such allegations—"complaints," in official language—are always fully supported by documentary evidence and cases for or against an airline are argued as carefully and expertly as in any civil court action. The three airline executives serving voluntarily as Commission members decide the outcome and, where applicable, what the penalty shall be.

At this Commission, two matters turned what was otherwise a very routine affair into an event marking yet another stage in the deterioration of IATA's strength and standing. First, a South American airline, due to appear before the Commission to answer for certain breaches of the Association's rules, declined to do so, but, instead, wrote a polite letter withdrawing its recognition of the right of IATA to pursue enforcement investigations in its offices. This carrier also said, quite firmly, that it would disregard the findings of the Commission and any penalties that it saw fit to impose. Obviously, the company involved must have weighed most carefully the full possible effect of its action and of the loss of IATA membership which could conceivably follow. Clearly, it is not particularly worried at the prospect.

The other matter had its beginnings in Athens in April and May of this year. There, acting upon the instructions of the New York headquarters of IATA's Enforcement Section, two of the Association's enforcement officers, through a locally employed assistant, purchased "test" passenger tickets from several airline offices at substantial discounts. As a matter of routine the officer in charge of the investigation then called upon each IATA member involved, advised the senior representative of his findings and stated that the matter would be reported to a Breaches Commission.

Within a few weeks, an employee of one of these airlines, supported by sworn affidavits from "witnesses," set in motion a criminal action against the two enforcement officers and their assistant and police investigations ensued. Not one airline district manager came forward at the time to testify to the absurdity of the charge on the grounds that the accused men had acted in accordance with a routine and recognized procedure.

In fact, as the Commission got under way the news came through that the courts had dismissed the charges as groundless. But between June and November volumes of correspondence and many cablegrams were exchanged, costly legal services were retained by the airline plaintiffs and IATA, and top executives on both sides of the Atlantic were forced to dissipate their energies in pressing and defending an action which should never have reached the law courts.

This is no place to discuss the pros and cons of IATA enforcement, or its methods. But member airlines of the Association contribute to its policies as well as to its treasury and are well aware of the need for investigators to have a free hand in carrying out "test-purchase" procedures in areas where illegal discounts are known to be offered. It would therefore appear to be the height of folly for head offices of members to have allowed a prosecution to be instigated and thus have placed IATA in the embarrassing position of having to defend itself against its own subscribers.

The fact that the managements of the airlines involved did not view the matter with greater concern and halt the proceedings before they went too far, seems, our correspondent adds, to point to a lack of a sense of responsibility towards their own industry association. It can only be hoped that this sign of waning respect will deliver a wakening jolt to those who are blind to the Association's diminishing authority in the airline industry.

The Air-freight Business

BY way of expansion of the comments about freight rates in this column in the November 20 issue (p. 501) it appears that the 87 airlines, which, together, are IATA, form a bigger composite nigger in the rates woodpile than is generally imagined.

Obviously there must be compromises—thousands of them—in any series of inter-airline agreements, but, because of the power of the veto in a unanimous-decision system, quite economic special commodity rates are sometimes thrown out just because one airline happens to find it more profitable to carry postcards than washing machines.

Another factor is the cumulative effect of arranging freight rates so that they are in workable round figures. The result of working to the nearest penny or cent can mean, for instance, that an "across the board" increase of 5% may involve very much greater increases in specific cases.

But the really unsatisfactory feature of rate agreements is the simple one—that an operator with capacity to spare cannot go along to the shipper and negotiate a special rate for a special circumstance. The result is not only that maximum day-to-day use of available capacity is impossible but that there is no encouragement for the principle of air-freighting against the day when the agreed rates may be a little more commercial than they are at present.

Last week's reference to relative contributions to the overall BIATA traffic figures leads to another question: is there any single satisfactory yardstick for measuring the amount of work being done by any particular operator? Neither tons uplifted nor ton-miles performed are necessarily giving anything like a fair answer. For instance, Silver City's 87,003 short tons amounts, as we pointed out, to 75.6% of the total BIATA uplift for 1958-59, but the ton-miles involved might amount to no more than 5% of the Association members' combined scheduled and non-scheduled total.

Yet this percentage provides an equally unrepresentative picture since, in terms of ton-miles, it might be necessary to complete 250 Channel vehicle-ferry crossings—with all that these involve in work on the ground and in the air—to equal

STRANGE LIVERY.—No, Qantas has not bought Comet 4s. The explanation of this photograph from Singapore is that the Australian operator charters a B.O.A.C. Comet for one of the nine weekly services now operated by the Kangaroo partners over the eastbound London-Sydney route. The Comet operates over the sectors between London and Singapore and a Super Constellation over the sectors between Singapore and Sydney.

RUSSIAN TURBOPROP.—This new picture of one of the Antonov An-10s in service with Aeroflot shows the anhedral of the outer wing panels and the end-plate fins introduced in the course of test development.

Air Transport . . . .

one comparatively easy and uneventful freight trip on the Singapore run. Presumably the actual effort involved in a series of flights can be adequately assessed only by means of a formula which includes both the man-hours involved and the ton-miles performed.

Some operators are, in fact, completely disinterested in any normally used traffic statistics. The figures of interest to them are the cost and revenue per hour; they are selling flying hours and are concerned only with the cost per hour and the price which is being paid for the use of that hour's flying.

Co-ordinating A.T.C. Policy

THE Air Traffic Control Board—the formation of which was announced by the then Minister of Transport on July 29 and reported in our issue of August 14—has held its first meeting. The Board, which replaces the Interdepartmental Aircraft Control Committee, is designed to co-ordinate the work of all A.T.C. authorities; to formulate policy; to co-ordinate the presentation of this policy in negotiations within ICAO; to submit reports to ministers concerned; and to direct the efforts of the Air Traffic Control Executive, on which the Board relies for detailed or executive work.

It consists of a chairman and representatives of the Ministry of Aviation (previously M.T.C.A. and M.o.S.), the Air Ministry and the Admiralty. The present membership consists of Sir Frederick Brundrett (chairman), M. M. V. Custance, Dr. J. McPetrie, Gp. Capt. J. B. Veal, Air Marshal Sir Edmund Hudleston, R. H. Melville, Vice-Admiral L. G. Durlacher and Capt. J. R. W. Groves.

Traffic and Profitability

STUDIES of the prospective profitability of different transport aircraft have tended, in the past, to have been tied closely to operating costs in ideal situations rather than to actual costs and revenues in day-to-day operation over particular routes with their actual traffic potentialities. An aircraft's prospective profit-making ability obviously cannot be assessed solely in terms of a break-even load factor.

For instance, over a sector normally providing only 50 passengers per flight, an 80-seater aircraft which can break even on costs at a 50% load factor will make a profit, whilst a 130-seater, which can break even at 40%, will not. This self-evident fact may not always be appreciated and is specially important in the case of an aircraft such as the medium-capacity Comet when it is being compared with a larger-capacity aircraft. The de Havilland Sales Engineering Department has done a series of calculations (based, for convenience of comparison, on the standard A.T.A. costing method) to demonstrate the effect of this approach in a specific case and explains the results in these terms:

"Let us assume that an airline purchases a fleet of three Comet 4C aircraft for a thrice-weekly service on a route such as that from Europe to Tokyo. The Comet 4C has been chosen as being well suited to this route, where stages of around 1,500 naut. miles are flown. As a typical competitor, we have chosen a medium-range jet which we shall call 'Jet A.' . . ."

The Comet breaks even "at eight passengers fewer than does Jet A on a 1,500-nautical-mile stage. This means, in terms of total passengers over the three flights in each week, that the Comet 4C will more readily allow a change in its frequency than will the larger aircraft; in other words, the increased cost of operating a further flight can be sustained with greater ease. This factor is of extreme importance, as frequency leads to increased traffic. . . .

"Initially, 150 passengers travel on this route each week and traffic increases at 10% per annum, until the passenger load factor reaches 75% of capacity. At this point, the frequency is changed and, as well as the 10% per annum increase, there is a further addition in traffic at the rate of half the percentage increase in frequency, which is assumed to happen over three months. This increase is not natural growth, but is acquired at the expense of the airline that is not offering such an attractive frequency.

"The build-up of frequency is . . . [such] that the Comet can increase its frequency only 2½ years after the start of the operation, and thereafter at ever-decreasing intervals, whereas the larger aircraft is obliged to remain at its initial frequency until at least six years from the start of operation.

"Taking this to the final stage, the Comet 4C compared with Jet A achieves considerably more profit in each year. Its lower break-even number of passengers gives it a lead in the first year of operation. . . . Even taking into account the purchase of a fourth Comet during the fifth year of operation, to give the required capacity, the aircraft is still leading. The Jet A fleet can remain at three throughout the operation, but in spite of its initially larger capacity it makes less money."

B.E.A. Results and Prospects

TRAFFIC on B.E.A. services during September was 20% above the level in September, 1958, and the revenue load factor was 74.6% against 64.4%. These results rounded off a six-month summer season in which B.E.A. carried 20% more traffic with only a 12% increase in capacity. September results are summarized below.

TRAFFIC—SEPTEMBER 1959/1958

	September 1959	September 1958	Variation
Capacity ton-miles offered	20,132,000	19,421,000	+3.7%
Load ton-miles sold	15,024,000	12,498,000	+20.2%
Revenue load factor	74.6%	64.4%	+15.8%
Passengers carried	388,933	331,937	+17.2%
Passenger miles flown	140,291,000	118,035,000	+18.9%
Passenger load factor	78.0%	68.4%	+14.0%
Freight ton-miles	1,288,800	993,400	+29.7%
Mail ton-miles	308,700	322,300	— 4.2%
Aircraft miles flown	3,953,000	3,837,000	+ 3.0%
Revenue hours flown	20,453	20,808	— 1.7%

B.E.A. is now embarking on a period of transition and expansion which will inevitably influence its expenditure in the 1959-60 accounts, and more especially the 1960-61 accounts. The task of training 90 pilots on the Comet 4B has already begun, and during the coming winter months a total of 350 B.E.A. pilots will be taking conversion courses on Comets, Vanguards or Viscounts. Standing charges will have to be borne on new aircraft for several months while they contribute little or no revenue, and training and familiarization courses on the new aircraft have to be provided for traffic, engineering and other specialist staff.

In 1960, B.E.A. will increase its capacity by about 20% over 1959, compared with an increase of only 5% this year. A big factor in filling this extra capacity will be the introduction of lower fares on selected routes (see our issue of November 20, p. 497).

Only the VANGUARD

paces the jets at much less than half the cost

ALL ROUND Europe, and on record flights in Canada, the Vickers Vanguard has been logging block times which have proved that on short and middle distance routes it can more than hold its own with the jets. It has, in zero wind, beaten current jet schedules on sectors as long as London-Rome (955 st. miles). It has flown London-Gander (2,365 st. miles) in 5 hours 30 minutes, and Toronto-Montreal (335 st. miles) in a record 58 minutes in zero wind.

Other Vanguard block times are:

LONDON-BRUSSELS
230 miles in 45 minutes (5 m.p.h. headwind).

LONDON-HAMBURG
470 miles in 73 minutes—a record (17 m.p.h. tailwind).

LONDON-PARIS
224 miles in 41 minutes (zero wind).

PRESTWICK-KEFLAVIK
920 miles in 2 hours 35 minutes (zero wind).

KEFLAVIK-MONTREAL
2,360 miles in 6 hours 2 minutes (30 m.p.h. headwind).

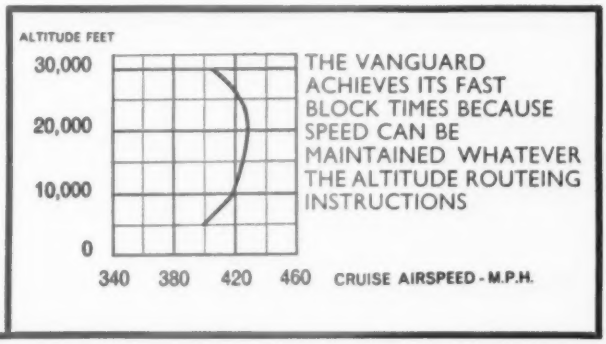
The Vanguard has achieved these block speeds at costs nearly one-third of those of comparable pure jet aircraft.

Recent U.S.A. figures show jet aircraft flight hour direct costs as 2.8 times greater than those of the Vanguard, and seat mile direct costs 2.6 times as great.

The Vickers Vanguard has, without doubt, the biggest profit potential ever offered to the airline industry—and it offers it at proved realistic competitive speeds.

The Economy Class cheap-fare capabilities of the Vanguard are at the forefront of the now established world movement for popular air travel. Only the Vickers Vanguard can bring these vast new markets to the Airlines on short and medium haul routes, at a substantial profit, and the Vanguard can do this with schedules as fast, if not faster, than any other aircraft.

Vanguard costs used in this comparison are to A.T.A. formula. Both the Viscount 745 and the Viscount 810 filed costs have been proved in practice to be substantially below such A.T.A. formula costs.



Of all the airliners only the Vanguard has all these features

425 m.p.h. cruising • Freight capacity 7/8 tons at normal densities • Full routeing and A.T.C. flexibility • Can use normal existing airfields • Quick turn-round • No airfield noise problems • Ten years' unique Vickers/Rolls-Royce turbo-prop experience . . . ***And it is 'Viscount' quiet.***

VICKERS VANGUARD

FOUR ROLLS-ROYCE TYNE TURBO-PROP ENGINES

• ***The airliner with the biggest profit potential ever offered to the operator***

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED WEYBRIDGE SURREY

AT 627

D

Eland turbo-prop engine

breaks into United States market

D. Napier and Son Ltd. announce that an agreement has been signed by Allegheny Airlines Inc. with Napier Engines Inc. the Company's wholly-owned subsidiary in the United States, covering the purchase of a fleet of turbo-prop powered Convair 540s equipped with Napier's Eland 3,500 e.h.p. propeller turbine engines. Yet another triumph for Napier Engineering.

NAPIER ELAND TURBO-PROP

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A MEMBER OF THE ENGLISH ELECTRIC AVIATION GROUP

Air Transport . . . .

Guidance for the Controllers

LIKE those of flying instructors, the skill and experience of air traffic controllers have tended to be built up, so to speak, from generation to generation—starting in the days when Jimmy Jeffs leaned out of a control-tower window at Croydon to give the radio operator "motors east," "motors over," or "motors west" information to pass on to an invisible aircraft. During the years a great deal of assorted information, such as that in the "Air Pilot," has been available about procedures and methods, but there has been no consolidated source of specialist knowledge.

This gap has now been filled by "The United Kingdom Manual of Air Traffic Control"* which was produced by the Ministry of Transport and Civil Aviation before the air transport side of the organization became a part of the new Ministry of Aviation. Its primary object is to meet the needs of A.T.C. officers, and in its complete form it carries detailed area and local instructions, but it is also intended to be of general assistance to everyone concerned with civil aviation and Part 1 of the manual is available (with amendments) for public purchase in the ordinary way.

This main section includes eight sections (plus two not yet allocated) giving, first, the appropriate definitions and, later, complete procedural and administrative information, with a final instructional part dealing with "supplementary" or more recently introduced procedures.

* H.M. Stationery Office, £3 5s. (or £3 7s., by post in the U.K. from H.M.S.O., P.O. Box 569, London, S.E.1).

The Anzio Collision Report

THE Italian Ministry of Defence Commission's report on the collision between a B.E.A. Viscount and an Italian Air Force F-86E on October 22, 1958, was issued last week. The cause was given as the deviation of the Viscount—which, with 26 passengers and five crew members, was flying from London to Naples—from Airway Amber 1 into a prohibited area reserved for military activity. All on board the Viscount lost their lives, but the F-86 pilot, the leader of a line-ahead formation, survived following the fortuitously inadvertent opening of his parachute. The reason for the deviation from the airway was due, in the majority view of the inquiry commission, to imperfect navigation.

The recommendations of the commission were that areas prohibited for military reasons should be moved from the vicinity of control areas and airways; that radio navigation facilities should be modernized and simplified; that aircraft should have aids appropriate for use on the routes flown; that radar facilities should be provided; and that the attention of pilots should be drawn to the necessity for absolute compliance with air traffic rules. According to the report this particular prohibited area was, during 1958, crossed 36 times—and 14 of these deviations were after the date of this collision disaster.

North Atlantic Traffic Trends

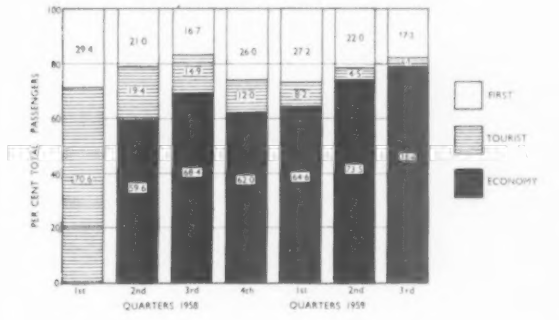
THREE main features characterize the IATA carriers' North Atlantic traffic figures for the third quarter of 1959—the way in which economy class passengers (78.6%) have squeezed the tourist ratio down to a mere 4.1%; the rise in the overall passenger load factor to 72.2% (the highest figure since the second quarter of 1957); and the continued increase in air freight, which has topped the 8,210-tonne mark. (The figures and graphs for the second quarter appeared in our issue of September 4, p. 89.)

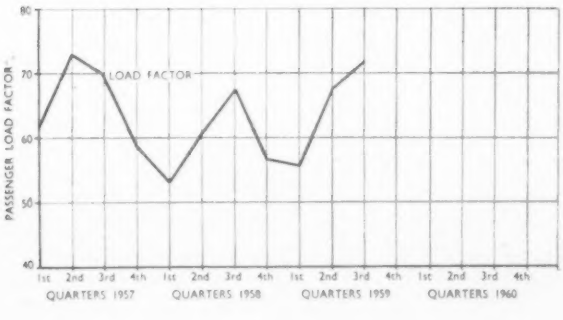
The cargo figure shows, in fact, an increase of 24.5% on that for the same quarter of 1958 and is a repetition of large increases amounting to a 34% rise for the first nine months of this year by comparison with those of 1958. Scheduled passenger traffic numbers were 12% larger for this past quarter than for the third quarter of last year.

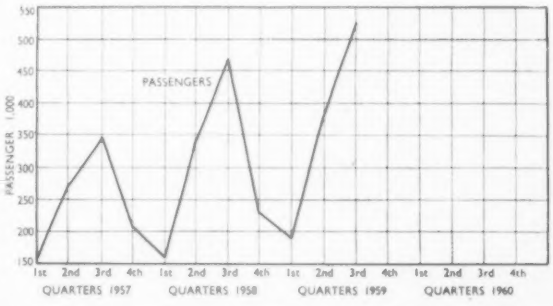
By comparison with the third quarter of 1958 tourist traffic has decreased by 69%; first-class traffic has increased by 16.2% (to 17.3% of the total); and economy class traffic has increased by 28.6%. The drop in tourist travel has been at least partly due to a decline in the capacity offered—but this decline has, in its turn, been the result of estimates by the airlines of the falling demand, and the accuracy of this estimate is shown by the fact that the tourist load factor was no more than 58.7% during the past quarter.

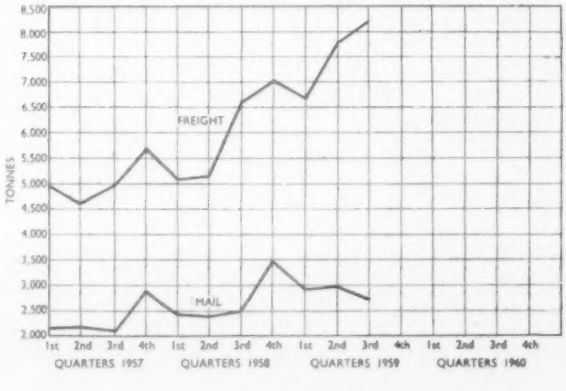
3rd Quarter, 1959

	East-bound	West-bound	Total	% Change 1958
Scheduled flights	5,005	5,061	10,066	— 1.8
Seats offered	358,342	366,404	724,746	+ 5.2
Revenue passengers :				
First	41,499	48,705	90,204	+ 16.2
Tourist	8,894	12,661	21,555	— 69.0
Economy	171,390	239,882	411,272	+ 28.6
Total	221,783	301,248	523,031	+ 12.0
Pass. load factor, %	61.7	82.1	72.2	+ 4.4
Freight, kg.	3,862,578	4,348,237	8,210,815	+ 24.5
Mail, kg.	1,542,530	1,233,869	2,776,399	+ 10.9









Allegheny—First Eland Operator

ALLEGHENY AIRLINES, which recently ordered five Napier Eland-powered Convair 540 conversions (THE AEROPLANE AND ASTRONAUTICS, November 20), is one of the group of U.S. local service airlines which are now passing through a phase of re-equipment and expansion. At least six of these airlines, which operate feeder services for the trunk routes throughout the continent, have introduced Fairchild F-27s in the past year or so, but Allegheny delayed ordering new equipment until it had an opportunity of evaluating other suitable turboprops. In addition to the usual paperwork, this evaluation has included a period of trial operations with a prototype Napier-Convair conversion, the results of which have obviously influenced the airline's re-equipment decision.

Thirty-three cities are served by Allegheny in the 10 Middle Atlantic states, including New York, Washington/Baltimore, Philadelphia, Detroit, Buffalo, Pittsburgh and Cleveland. The present fleet consists of 13 Martin 2-0-2s and 12 DC-3s, in addition to the leased Eland-Convair.

Operations with the Eland-Convair (which is N440EL, the 440 converted by PacAero in 1958 and used for C.A.A. certification) began on July 1 but suffered an early set-back when the engine bearings were found to have suffered Brinelling during road transportation. With new engines (supplied on a re-designed transport rig), the aircraft went back into service on July 31 on the Pittsburgh-Atlantic City route and by September 24 had completed 404 flights at an availability rate of 99.51%.

During August, the first complete month of operation, Allegheny achieved an average daily utilization of 6 hr. 10 min. with the Convair, compared with 5 hr. 7 min. average for the DC-3 and 5 hr. 16 min. for the Martin. Scheduled miles flown per hour were, respectively, 262.5, 138.1 and 176.5. Available seat miles produced by the single 44-seat Convair totalled 1.9 million in the month, compared to 12.7 million produced by 13 Martins and 6.1 million by 11 DC-3s.

Earned revenue of $83,759 in August worked out at $1.92 per revenue mile on the Convair. Comparative revenue rates of the Martin 2-0-2 and DC-3 were $1.77 and $1.27 respectively. Direct operating expenses, at 97.47 cents per revenue mile, were slightly higher than the Martin costs of 93.45 cents; the DC-3 figure was 64.40 cents. These direct costs were, however, unrepresentative of future Convair 540 operations, because they were based on the "first cost" of a new Canadair 540 ($1.4 million) and equivalent insurance rates. The conversions which Allegheny have ordered will be 56-seaters and are expected to have seat-mile costs as low as 1.5 cents, or about 75% of the prototype costs in August.

These figures, for a single trial month on one route (where traffic was depressed by the U.S. steel strike) are no more than an indication of the economic performance of the Eland-Convair which led Allegheny to place their recent order, including an option on a further 10. The decision is of particular interest in that this airline is not already a Convair operator; second-hand 340s or 440s have to be purchased and the conversions made. Current quotations on the Aircraft Exchange are in the range of $300,000-$400,000 per aircraft. Adding to this the cost of two new Elands (at about £38,000 each plus 12½% U.S. import duty) and the cost of conversion, which will be undertaken by a U.S. company as contractor to Napier Inc., a total cost per aircraft in the region of $700,000 seems possible. This compares with the current F-27 price of $720,000—and the Convair seats 56 against the F-27's 44.

Sir Archibald Hope (left), Napier's director of sales (air), with Mr. Leslie O. Barnes, president of Allegheny Airlines, which last month signed an agreement covering the purchase of five Eland-Convair conversions.

Also considered by Allegheny was the Allison-Convair conversion, which has two Electra-type powerplants containing 501D-13 engines. A prototype conversion is being made by PacAero for certification trials next year. Backed by a major production programme and with no import tax, the Allison engine sells at about 75% of the American price of the Eland. It is, however, a little more powerful than the Eland and, as a result, a new tail unit has to be used, increasing the cost of conversion.

No-reservation Flights

Allegheny renewed its lease of the Eland-Convair for a further three months from the beginning of October, and on October 4 began a revolutionary commuter-type service with three round trips daily on the Pittsburgh-Philadelphia route. The philosophy behind this new service is that reservation of seats, pre-ticketing procedures, baggage checking, and so on, which are time-consuming and costly, are not required by many commuters on local services. A special fare of $13.00 has therefore been established on this service for passengers who are content simply to turn up at the gate 30 minutes before the aircraft's departure and take their chance that a seat will be available.

Seats are still sold, at a fare of $20.30, on a reserved basis. Commuters with no reservations time-stamp a card upon arrival at the departure gate and board the aircraft in order of arrival time when other passengers have been accommodated. Once on board, all passengers receive precisely the same service, regardless of the fare they have paid. No-reservation passengers can check their baggage for a fee of $2 if they do not wish to carry it on board themselves.

The Eland-powered Convair 340/540 which made a two-month sales tour of the U.S.A. last summer. This is N340EL; the aircraft used by Allegheny for evaluation was N440EL, converted by PacAero in 1958 and used for certification.

Photograph copyright "The Aeroplane and Astronautics"

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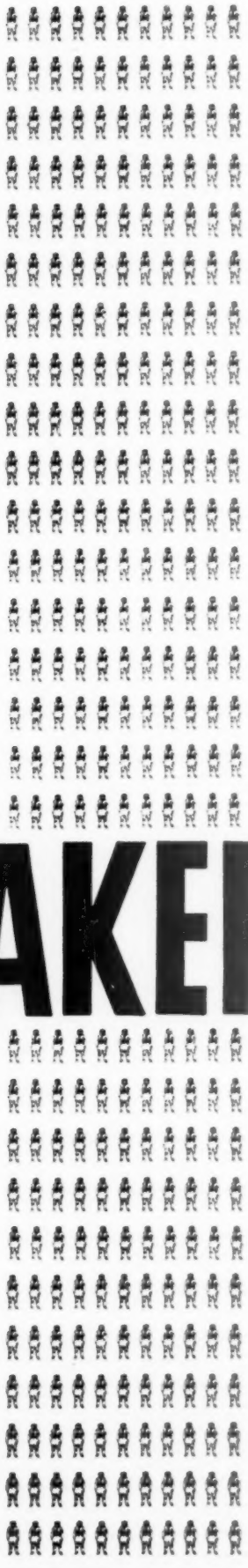

MARTIN-BAKER
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The Fighting Services

To Command No. 38 Group

AIR COMMODORE P. G. Wykeham, D.S.O., O.B.E., D.F.C., A.F.C., has been appointed the first commander of No. 38 Group, the new Transport Command specialist tactical air transport formation. Director of Operations (Fighter and Theatre Air Forces) at the Air Ministry since May, 1958, Air Cdre. Wykeham will become the Group's A.O.C. on January 1, with the acting rank of Air Vice-Marshal.

Announced last month, No. 38 Group will have its Headquarters at R.A.F. Upavon and a number of the staff posts will be filled by Army officers. In addition to handling the air support of the Army, in particular the tactical movement of its Strategic Reserve, the Group will be available to assist overseas Commanders-in-Chief in the control of major transport operations in their theatre.

First and Last

COMMANDED by Lieut. Cdr. A. G. B. Phillip, R.N., No. 849 Squadron operating Douglas AD-4W Skyraiders is to start re-equipping with Fairey Gannet AEW.3s. The largest of all Fleet Air Arm squadrons, and the last to be equipped with fixed-wing piston-engined aircraft, No. 849 has its Headquarters Flight at R.N.A.S. Culdrose and operational flights, each with four aircraft, on board the carriers in commissioned service.

Fifty Skyraiders were received under the American mutual aid programme by the Royal Navy for AEW duties during the early stages of the Korean War in 1950, and since it was re-formed in July, 1952, No. 849 Squadron has flown some 45,000 hr. and over 7,500,000 miles with the aircraft. During this time it has had one fatal accident only.

In addition to administrating the detached flights at sea, the Headquarters Flight at Culdrose is responsible for training pilots in AEW operations and in the Squadron's other tasks. These include anti-submarine search, long-range surface search and strike direction in all weather conditions, and weather reconnaissance duties. The aircraft in the detached flights spend 13 months at sea, and then return for overhaul and modernization at Culdrose.

To mark the end of Skyraider service with 849 Squadron, Mr. L. C. Posley, of the Douglas Aircraft Co., recently presented Lieut. Cdr. Phillip with a gold trophy which included a model of the Navy's first AEW aircraft.

R.A.F. Appointments

THE following are among recent Royal Air Force appointments:—

Air Ministry: Wing Cdr. T. R. Pierce to the Department of the Chief of the Air Staff, with the acting rank of Gp. Capt.; Wg. Cdr. W. H. Webber to the Department of the Air Member for Supply and Organization.

Fighter Command: Sq. Ldr. J. R. Davies to Headquarters, No. 13 Group, as Chief Signals Officer, with the acting rank of Wg. Cdr.

Flying Training Command: Wg. Cdr. J. D. Thirlwell, O.B.E., D.F.C., to the R.A.F. Flying College, Manby, as Senior Instructor.

Technical Training Command: Gp. Capt. L. Kelly, O.B.E., B.Sc., to the R.A.F. Technical College, Henlow, as Assistant Commandant; Gp. Capt. H. H. Mayoh, B.Sc., to R.A.F. Henlow, for specialist duties.

Maintenance Command: Wg. Cdr. T. R. F. Handcock, to Headquarters, No. 40 Group.

SKYRAIDER TROPHY.—The C.O. of No. 849 Squadron, Lieut. Cdr. A. G. B. Phillip, R.N., receiving a gold trophy from Mr. L. C. Posley of the Douglas Aircraft Co., during a recent ceremony at R.N.A.S. Culdrose. Operating Skyraiders since July, 1952, the Squadron is re-equipping with Gannet AEW.3s.

Signals Command: Wg. Cdr. A. A. Solly to the Radio Equipment Unit, R.A.F. Henlow, as senior equipment officer.

Middle East Air Force: Wg. Cdr. G. E. F. Goode, O.B.E., D.F.C., B.Com., to Headquarters for work study duties; Sq. Ldr. G. Mackie to Headquarters for planning duties with the acting rank of Wg. Cdr.

British Forces Arabian Peninsula: Wg. Cdr. D. Nelson to Headquarters as Command Armament Officer.

Far East Air Force: Wg. Cdr. N. B. Freeman, A.F.C., to R.A.F. Changi to command the flying wing.

R.A.F. Germany: Gp. Capt. W. A. Toyne, D.F.C., to R.A.F. Sylt, to command; Gp. Capt. R. H. Waterhouse, C.B.E., D.F.C., A.F.C., to Headquarters as Senior Personnel Staff Officer.

R.A.F. Malta: Gp. Capt. C. V. D. Willis, D.S.O., O.B.E., D.F.C., to R.A.F. Luqa to command.

Other Appointments: Gp. Capt. A. H. W. Ball, D.S.O., D.F.C., to the U.S.A., for duties with the British Joint Services Mission; Wg. Cdr. J. M. Morgan, D.F.C., to Lima (Peru) as Air Attaché, with the acting rank of Gp. Capt.

More Service News

Specialist Navigation Association.—It is proposed to form a Specialist Navigation Association which will be open to all graduates of the course at the R.A.F. Flying College, Manby, since its inception. The first dinner will be held in July, 1960, to coincide with the graduation of No. 18 Specialist Navigation Course. Details can be obtained from Wg. Cdr. H. L. Lewis at R.A.F. Manby, Louth, Lincs.

R.A.A.F. Sidewinder Trials.—A Jindivik was destroyed by a Sidewinder AAM fired from an R.A.A.F. Sabre over the Woomera rocket range last month. This was the first Sidewinder to be fired against a Jindivik, and it was launched at an altitude of over 40,000 ft.

"HERMES" IN SERVICE.—Following the completion of full power trials on November 18, H.M.S. "Hermes" was accepted for the Royal Navy by Capt. D. S. Tibbits, D.S.C., R.N. Built by Vickers-Armstrongs, the 22,000-ton carrier starts her first commission this month and will embark Scimitars, Sea Vixens, Whirlwinds and Gannet AEW.3s in the New Year. On the forward starboard side of the flight deck can be seen the carrier control approach (CCA) radar aerial.

Astronautics and Missiles

Probes to Venus and Mars

Later this month, it is reported, the Americans will launch a five-stage rocket towards Venus. Here S. W. GREENWOOD, *M.Eng., A.M.I.Mech.E., A.F.R.Ae.S., considers what is involved.*

THE Moon has been passed, hit, and viewed from its far side, and is due to receive further attentions in the future. Yet the Moon is an inseparable companion of the Earth in its journey round the Sun, and interplanetary flight in a literal sense has not yet begun. The first objectives in interplanetary exploration will undoubtedly be the sending of probes to Venus and Mars

Elliptical Orbits

It will be remembered that both the Russian Lunik 1 and the American Pioneer IV are now in orbit round the Sun, and that they follow paths that lie roughly between the orbits of Earth and Mars. These, however, were strictly lunar probes, and their interplanetary journeys are almost incidental.

The relationship between the Earth and its two neighbour planets is shown in Fig. 1, together with some basic data on their orbits. In the diagram these orbits are represented as being circular and coplanar, for in many astronautic studies these simplifying assumptions have been made, and this can be of use in establishing orders of magnitude. However, in reality these conditions are not met, the orbits being elliptic and non-coplanar—and in some cases the errors arising from such assumptions are appreciable, as we shall see later.

Some familiar aspects of the motions of the three planets under discussion will be evident from Fig. 1. They all travel around the Sun in the same rotational direction. Venus lies between the Earth and the Sun, and so has a shorter path, a shorter year, and travels at a higher speed than the Earth. Mars lies beyond the Earth, and so has a longer path, a longer year, and travels at a lower speed.

As a result of these motions, the Earth periodically overtakes Mars, and is periodically overtaken by Venus. The occasion when Earth and Mars are on the same side of the Sun and in line with it is termed an Opposition, and such occasions occur about every two years and two months. When the Earth and Venus are in line and on the same side of the Sun, the occasion is termed an Inferior Conjunction, and this happens about every one year and seven months.

These occasions when the planet of interest is close to the Earth are not the most suitable for effecting a transfer, as they call for extremely high vehicle performance.

The problem for a probe which is not required to experience any appreciable powerplant operation, apart from the launching phase and small corrections for purposes of mid-course guidance, is the attainment of a velocity sufficient to permit escape from the Earth's gravitational field and entry into a suitable orbit around the Sun to intercept the target planet. It has long been known that the orbit requiring minimum vehicle velocity, assuming the simplifications of circular and coplanar planetary orbits, is a semi-ellipse between the two planetary orbits that touches these orbits at the points of departure and arrival (Ref. 1).

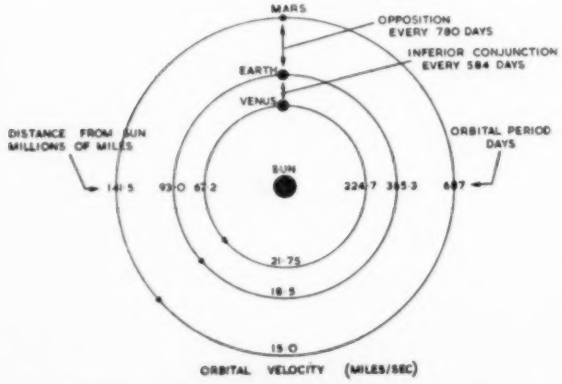

Fig. 1. Basic data on planetary orbits (assumed circular and coplanar).

Transfer along such an orbit, often described as a Hohmann orbit in honour of its first proposer, requires that the two planets be in a suitable position relative to each other at the time of launching. It follows, therefore, that such occasions recur at intervals of just over two years in the case of Mars

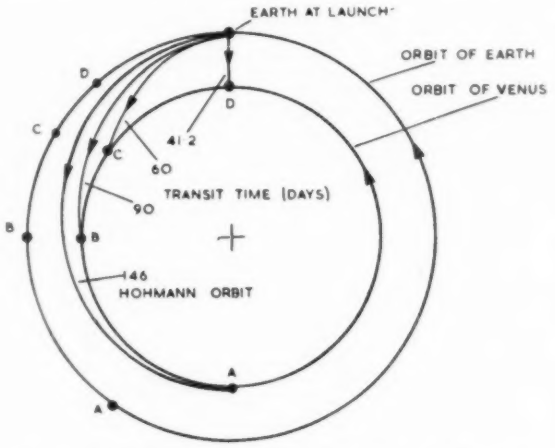

Fig. 2. Possible transfer orbits: Earth-Venus. (Letters show relative positions of planets at time of arrival at Venus.)

and of just over a year and a half in the case of Venus. Indeed this must be the case for any given orbit.

The Hohmann orbits are of rather long duration, and the question arises as to whether orbits of shorter duration might be preferable, although at the expense of a higher required vehicle performance. In terms of a given vehicle this would mean the projection of a smaller payload than was possible using a Hohmann orbit.

For the Earth-Venus transfer, some possible alternative orbits are shown in Fig. 2, based on data given in Refs. 2 and 3. In this case the transfer orbits are portions of ellipses touching the Earth's orbit at launch. Transit times may be very much reduced, although, as shown in the lower curve of Fig. 4, the penalty to be paid in the increased initial velocity requirement is significant.

Launching Periods

It is an easy matter to calculate that the launching period for the Hohmann orbit is about three months before Inferior Conjunction, and other orbits are spread within about three weeks of this, the launching date advancing as the vehicle velocity requirement is increased. This is, perhaps, a surprisingly narrow margin and indicates that the saving will be felt most directly in the duration of the transfer, and not in any flexibility in the launching date. However, greater flexibility in the launching date would obtain for launchings at an angle to the Earth's orbit.

More extensive results are available for the Earth-Mars transfer (Ref. 4), and transfer orbits of different initial velocities at different angles of initial inclination to the Earth's orbit

(*Continued on page 565*)

MILITARY MOBILITY

Bristol 192 helicopter demonstrates outstanding capability and versatility on Army exercise "Red Banner"

During the recent British Army exercise "Red Banner" held on Salisbury Plain, the Bristol 192 helicopter performed the role of tactical support vehicle with outstanding success.

In three consecutive sorties, the 192 carried (1) 10 men with full equipment plus 1,950-lb underslung freight; (2) transported 8 stretcher cases plus 2 sitting patients and (3) 4 stretcher cases plus 11 sitting patients.

Bristol 192, in quantity production now.

Backed by Bristol's 15 years of rotary-wing experience, the 192 is the first helicopter in quantity production with true twin-engine safety, and is due to go into RAF service in 1960. Powered by two Napier Gazelle NGa 2 free-turbine engines interconnected by a synchronising shaft, the 192 can hover on one engine at 95% of maximum gross weight.

The Bristol Sycamore, single-rotor helicopter has proved its efficiency in service and now has virtually no fixed retirement life on any of its components. The lessons learned from the Sycamore have been applied with great success to the Bristol 192.

BRISTOL 192 VERSATILITY

The most versatile army support vehicle ever produced, the Bristol 192 can act:—

As an aerial crane . . . carrying 6,640 lb slung beneath its fuselage.

As a transport . . . moving 18 fully armed men 200 miles, with ample fuel reserves.

As an assault craft . . . dropping 12 paratroopers (at 330 lb each) out to a radius of 120 miles from their base.

As an ambulance . . . with 12 stretcher cases plus 2 sitting patients and an attendant.

In all climates . . . the 192's performance in the tropics is unmatched by that of any other helicopter available now.

BRISTOL Aircraft

BRISTOL AIRCRAFT LIMITED

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Equipped by Marconi
to meet the
major radio requirements
of a modern airliner

MARCONI

COMPLETE AIRCRAFT AND AIRPORT RADIO SYSTEMS

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

M.2A

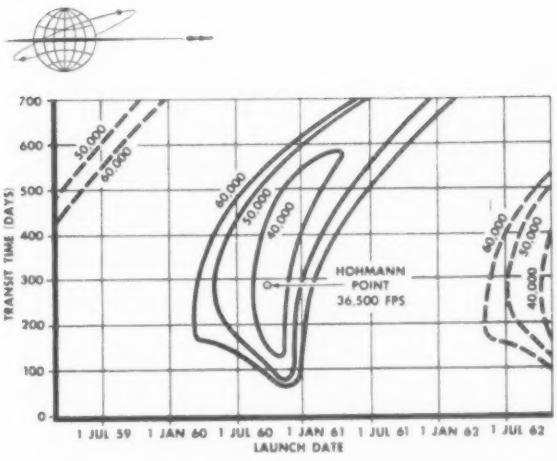

Fig. 3a. Effect of launch velocity on Earth-Mars transfer orbits (two-dimensional analysis). (From Ref. 4.)

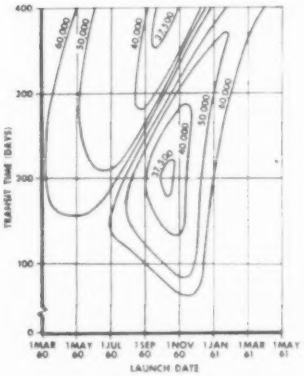

Fig. 3b. Effect of launch velocity on Earth-Mars transfer orbits (three-dimensional analysis). (From Ref. 4.)

(*Continued from page 564*)

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A comparison of Figs. 3a and 3b will reveal the significance

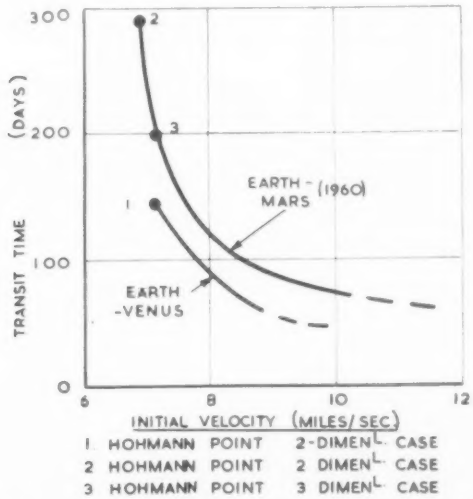
TRANSIT TIME (DAYS)
INITIAL VELOCITY (MILES/SEC)
EARTH - MARS (1960)
EARTH -VENUS
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Fig. 4. Influence of vehicle performance on transit time. (Adapted from Refs. 2 and 3.)

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The reductions in transfer time possible with increased vehicle performance are plotted as the top curve in Fig. 4, taking the data for minimum transit times from Fig. 3, the curve being roughly the same for both parts of the figure. The penalty involved in the faster transfers may again be seen.

A point of interest in Fig. 3 is that vehicles with higher initial velocities have a wider range of possible launching dates. A choice is offered between an early launching followed by a transfer orbit of long duration and a later launching followed by a transfer orbit of shorter duration.

In the data given in Fig. 3a the indication is that the early launching is preferable as this more than compensates for the increased duration of the transfer. But the more accurate data in Fig. 3b suggests that one effect will just about balance out the other.

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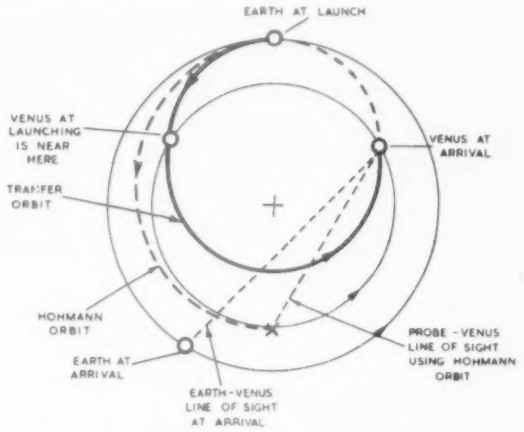
A fairly detailed summary of the factors affecting the launching of probes to Venus and Mars is given in Ref. 5. Detailed studies were made of transfer orbits to both planets, but only the results in the form of suitable launching periods are given.

It is considered that the favourable launching periods for Mars probes last about six to 12 weeks, depending on the available vehicle performance, whereas in the case of Venus the corresponding figure is about two weeks. The reason given for the restrictions on the Venus launchings is that only near-Hohmann orbits would be acceptable as these provide for a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TRANSFER ORBIT
HOHMANN ORBIT
EARTH AT ARRIVAL
PROBE - VENUS LINE OF SIGHT USING HOHMANN ORBIT
EARTH - VENUS LINE OF SIGHT AT ARRIVAL

Fig. 5. Possible orbit for Venus probe if launched on December 10, 1959: journey time 150 days.

fairly large separation of the target planet from a line joining the Earth and Sun at the time of the probe's arrival, as shown in Fig. 2. With the higher energy orbits the Sun would tend to be behind the planet as seen from the Earth during the flight of the probe, and this would hinder radio reception and optical tracking.

A table included in Ref. 5 is reproduced here, and constitutes a timetable for possible future launching periods. For those who wish for a simple reminder of these periods, the rough guide given earlier of about three months prior to Inferior Conjunction in the case of Venus and prior to Opposition in the case of Mars is seen to hold good.

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The Americans have stated that they intend to launch a probe to the vicinity of Venus in mid-December. One proposed launching date is about six months after the last opportunity for a Hohmann orbit meeting up with the target planet. There is some doubt, therefore, whether this will be the orbit selected, as when the probe reaches the orbit of Venus the planet would

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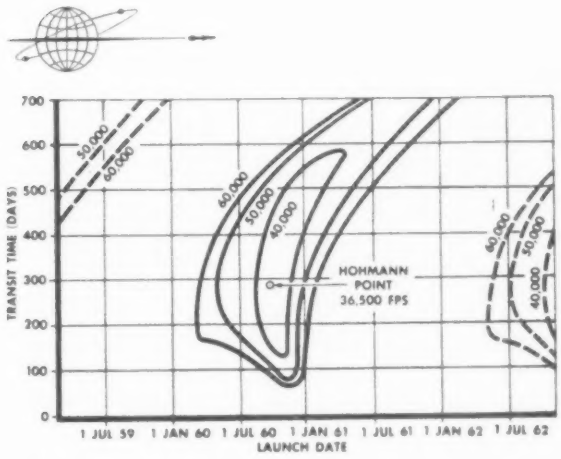

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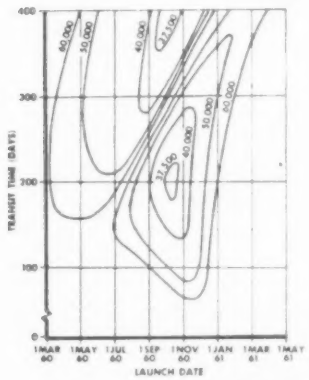

Fig. 3b. Effect of launch velocity on Earth-Mars transfer orbits (three-dimensional analysis). (From Ref. 4.)

(*Continued from page 564*)

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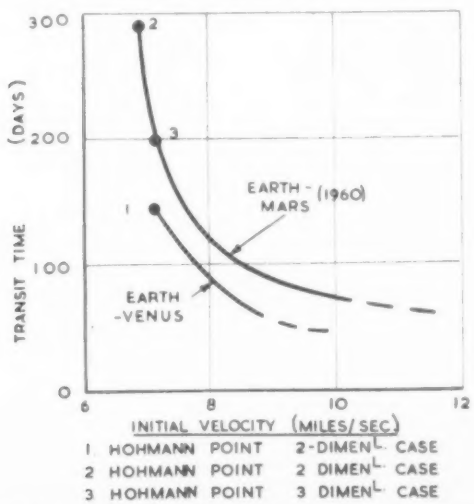
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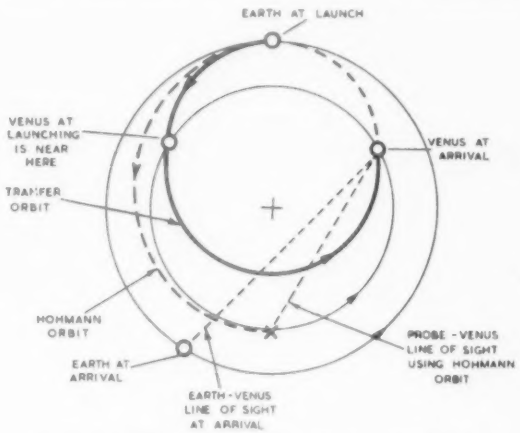
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TABLE 1 (Adapted from Ref. 5)

Target Planet / Year	Venus	Mars
1959	3-17 June *	—
1960	—	Aug.-Oct.
1961	11-25 Jan.	—
1962	8-22 Aug.	Sept.-Nov. *
1963	—	—
1964	18 Mar.-1 Apr.	Nov.-Jan. *
1965	27 Oct.-10 Nov.	—
1966	—	Dec.-Feb.
1967	7-21 June *	—
1968	—	—
1969	Jan.	Jan.-Mar.

* Opportunity for near-nodal transfer.

have moved ahead in its orbit as shown in Fig. 5. The distance separating the probe from Venus on arrival at the planet's orbit would, in fact, be about 120 million miles.

A possible orbit to follow, permitting the probe to meet up with the planet, would be one in which the probe travels on the long branch of a transfer ellipse as discussed in Ref. 3 and shown as a full line in Fig. 5. The duration would be about 150 days for a launching in mid-December, 1959. This is, coincidentally, the same as for a Hohmann orbit, and is the duration that has been quoted for the probe. It is, therefore, possible that such an orbit has been selected.

The disadvantages of this orbit appear to be threefold. In the first place, the velocity requirement is 8.1 miles/sec. compared with 7.1 miles/sec. for the Hohmann orbit. Secondly, the probe lies roughly in the same Earth-Sun line during the early stages of its flight and this is bad from the viewpoint of solar interference, as mentioned earlier. Finally, the probe will approach Venus when the planet is about 155 million miles distant from the Earth and this would increase the difficulties of tracking and the transmission of information.

Nevertheless, if successful, the venture should provide valuable experience in developing techniques for later interplanetary probes.

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(4) R. J. Gunkel, D. N. Lasocy and D. S. Merrilees, "Impulsive Midcourse Correction of an Interplanetary Transfer," paper presented at the 10th I.A.F. Congress, London, 1959.
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Atlas-Able Fails

A FAULT in the second stage of the Atlas-Able launching vehicle is blamed for the failure of the latest American Moon-probe, Pioneer V, to reach its objective. Launched on the morning of November 26 from Cape Canaveral, it was hoped that the 372-lb. probe would arrive in the vicinity of the Moon in 62 hours. When it was within 5,000 miles of the lunar surface, two retro-rockets were to have reduced its velocity from 4,500 m.p.h. to about 3,000 m.p.h., thereby allowing the Moon to "capture" the probe as a satellite.

In addition to the 2-lb. electronic scanner, designed to take elementary pictures of the Moon's surface, Pioneer V was instrumented to measure radiation, magnetic fields, micrometerorites, solar flare emissions, and the activity of "gaseous clouds of plasma floating in space."

The Atlas-Able comprised an Atlas ICBM as first stage, an Aerojet-General second-stage engine and a solid-propellent ABL motor as originally developed for the Vanguard satellite vehicle. The official NASA statement, explaining the mishap, was as follows: "The second stage telemetering signal stopped 70 seconds after launching and there was no record of the second stage having fired. We must presume that the second stage did not fire. Visual observation showed that pieces fell off the rocket."

It was the first launching of this particular combination, and since all existing rockets are scheduled for other projects, it is unlikely that the experiment will be repeated in the near future.

BLACK KNIGHT SUPPLIERS

ON pages 567-572 of this issue we present the first detailed description and cut-away drawing of the Saunders-Roe Black Knight re-entry test vehicle. Among the very large number of companies associated with this important research project and supplying equipment and materials both for the missile and its ancillary installations are the following:—

A.B. Metal Products, Ltd.; Aerolex, Ltd.; Aircraft Marine Products (Gt. Britain), Ltd.; Automotive Products, Ltd.; Autoset (Production), Ltd.; Aviation Developments, Ltd.; Avica Equipment, Ltd.; Belling and Lee, Ltd.; Bristol Siddeley Engines, Ltd.; British Aluminium Co., Ltd.; British Insulated Callenders Cables, Ltd.; British Refrasil Co., Ltd.; British Thomson Houston Co., Ltd.; Brown, S. G., Ltd.; Budenberg Gauge Co.; British Oxygen Gases, Ltd.; Chesterfield Tube Co., Ltd.; Ciba (A.R.L.), Ltd.; Counting Instruments, Ltd.; C.W.C. Equipment, Ltd.; Dowty Equipment, Ltd.; Electro-Hydraulics, Ltd.; Electronic Components, Ltd.; Electronic Precision Instruments, Ltd.; Elliott Bros. (London), Ltd.; Eric Resistor, Ltd.; Felco Hoist, Ltd.; Ferranti, Ltd.; Films and Equipment, Ltd.; Fireproof Tanks, Ltd.; Flight Refuelling, Ltd.; General Electric Co., Ltd.; Gloster Aircraft Co., Ltd.; Graseby Instruments, Ltd.; Graviner Manufacturing Co.

Hasset and Harper, Ltd.; Hellermann, Ltd.; High Pressure Components, Ltd.; H. M. Hobson, Ltd.; Honeywell Brown, Ltd.; Hymatic Engineering Co., Ltd.; Imhoff, A., Ltd.; I.V. Pressure Controllers, Ltd.; Kelvin and Hughes, Ltd.; Kodak, Ltd.; Marston Excelsior, Ltd.; M.B. Metals, Ltd.; Negretti and Zambra, Ltd.; New Electronic Products, Ltd.; Plannair, Ltd.; Pye, Ltd.; Radio Spares; Radio Supply Co.; Reid and Sigrist, Ltd.; Rellumit (London), Ltd.; Rist's Wires and Cables, Ltd.; Rotax, Ltd.; Sangamo Weston, Ltd.; Saunders Valve Co., Ltd.; Shell-Mex and BP, Ltd.; Smiths Aircraft Instruments, Ltd.; Solartron Electric Group, Ltd.; Sperry Gyroscope Co., Ltd.; Super Oil Seals and Gaskets, Ltd.; Teddington Aircraft Controls, Ltd.; Thermal Controls, Ltd.; Thorn Electrical Industries, Ltd.; Venner Accumulators, Ltd.; Williams and James, Ltd.; Laporte Industries, Ltd.

Supersonic Target

AS was briefly mentioned last week, Hawker Siddeley Aviation has signed a licence agreement with Nord-Aviation for the servicing, maintenance and manufacture of the C.T.41 supersonic target missile. This agreement is significant for two reasons. It represents another step in the closer association of the British and European aircraft industries which has been urged by the Government. It also means that if this target missile is produced here, it will allow the later versions of the Bloodhound, Thunderbird and Seaslug missiles to be tested against targets with a realistic performance. Many of the target drones used in the past have had far too low a performance to test surface-to-air missiles in representative conditions.

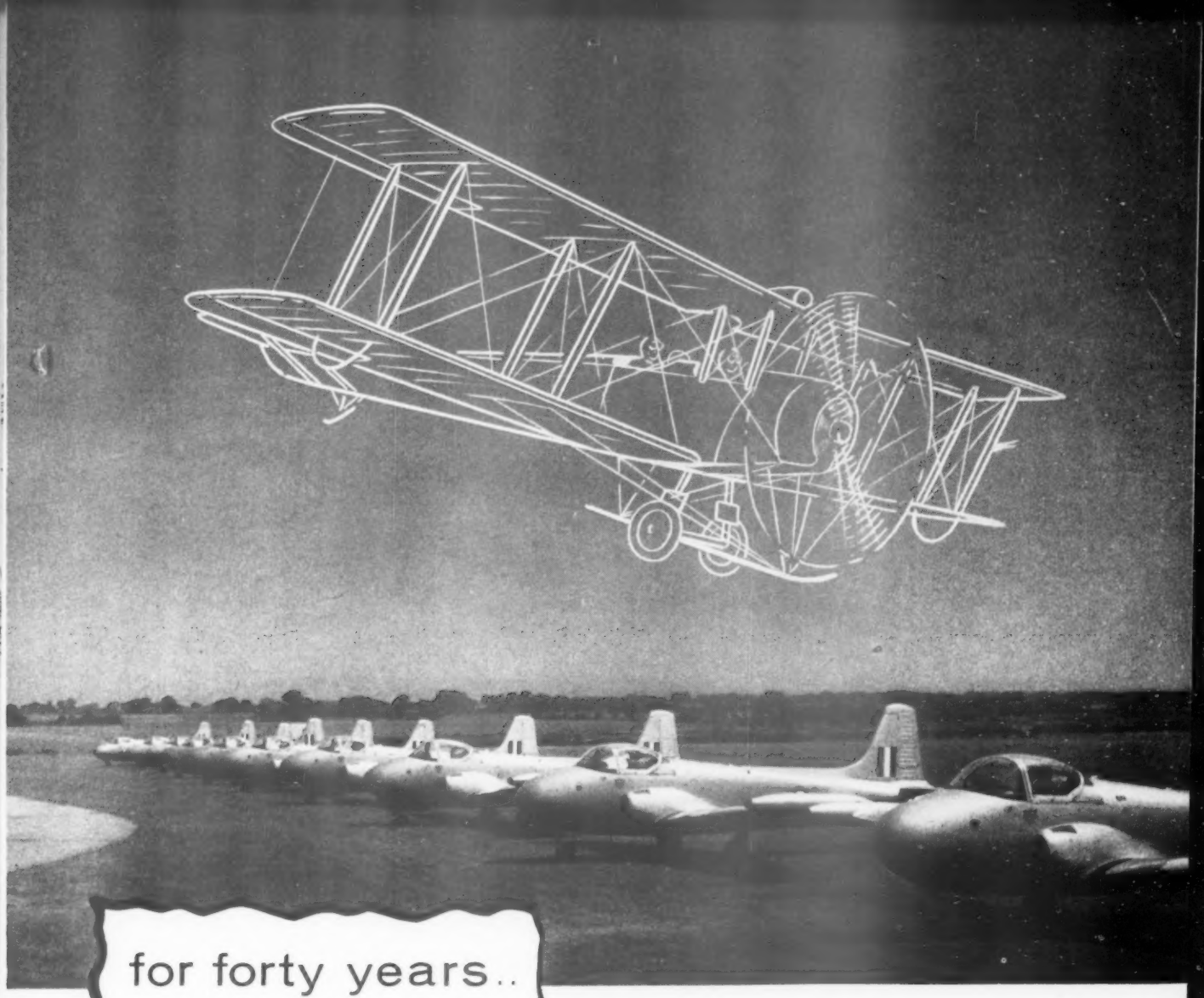
The C.T.41 is a supersonic twin-ramjet target missile whose design was begun in 1957; its development was assisted by experience with Nord's earlier target drones, the C.T.10 and C.T.20, both of which are in service at present. A recoverable radio-controlled drone, the C.T.41 has a canard configuration and is launched by two solid-propellent boosters. Its launching weight complete with boosters is 5,622 lb.; without boosters it has a loaded weight of 2,866 lb. and an empty weight of 1,764 lb. It has a span of 12 ft. 3 in. and is 32 ft. 2 in. long with a maximum fuselage diameter of 20 in.; its wing area is 33.3 sq. ft. It is designed for easy transport by air for which purpose the fuselage has been built in three sections.

Space Lectures

SPACE has found its way into the University Extension Lectures programme organized by London University's Department of Extra-Mural Studies. A course of lectures for non-specialists on "The Exploration of Space" is to be held at the City Literary Institute on Tuesdays at 18.00 hrs. from January 19 to March 22 inclusive.

M. O. Robins, M.A., of the British National Committee on Space Research, will lecture on "Objectives and App'ications" and on "Satellite Design and Launching"; Dr. A. P. Willmore on "Space Research and Rockets" and "The Ionosphere"; Dr. G. V. Groves, of University College, on "Satellite Orbits" and "The Upper Atmosphere"; W. T. Blackband, of R.A.E., on "Space Communications"; Dr. R. L. F. Boyd, of University College, on "Radiation and Astronomy in Space"; and Dr. L. R. Shepherd, chairman of the British Interplanetary Society, on "Interplanetary Travel."

The fee for the course is 8s., and particulars can be had from The Principal, City Literary Institute, Stukeley Street, W.C.2.



for forty years..

Forty years ago a party of flying instructors from the Royal Air Force School of Special Flying at Gosport left for the United States to demonstrate the revolutionary methods of teaching the Art of Flying devised by the late Colonel Smith-Barry.

Since those days it is fair to assert that every major change in instructional technique and flying-training equipment has been evolved in Britain, and in the course of time the World's air forces have followed suit.

And Now

The Hunting Jet Provost TMk 3, the latest primary/basic trainer—chosen by Royal Air Force Flying Training Command.

In full quantity production, it is also available for early delivery to other Air Forces.

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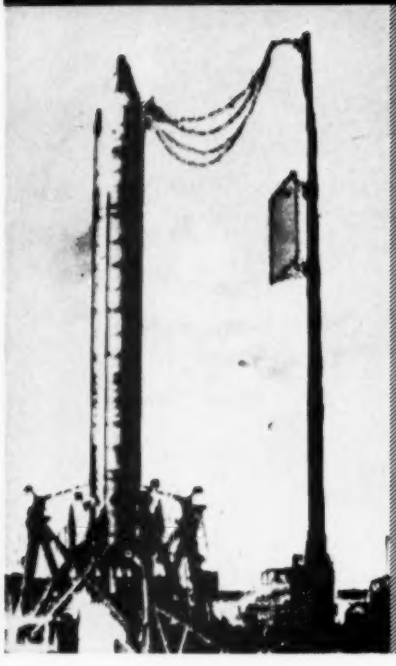
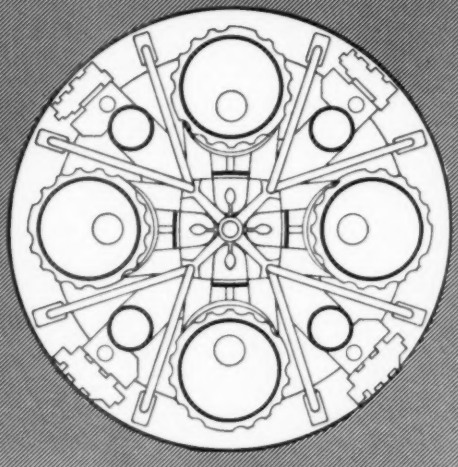
AP388

Gamma rocket engine delivers 19,000-lb thrust outside the earth's atmosphere – for a weight of under 700lb . . .





End view showing combustion chambers which can be inclined for vehicle guidance.

...ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Gamma. A liquid propellent rocket engine, the Gamma delivers 16,400-lb thrust (7,438 kg) at sea level rising to 19,000 lb (8,618 kg) outside the earth's atmosphere for a total engine bay weight of under 700 lb.

The Bristol Siddeley Gamma has four gimbal-mounted combustion chambers which are hydraulically actuated for vehicle guidance. Each combustion chamber is fed with propellents by its own turbopump unit and the four units are joined at the centre by a common manifold. The Gamma burns hydrogen peroxide (HTP) with kerosene and uses silver-plated nickel gauze as a catalyst to decompose the HTP into oxygen and superheated steam.

Gamma powers Black Knight

The Bristol Siddeley Gamma powers the Saunders-Roe Black Knight, Britain's highly successful space research vehicle. The Gamma has proved itself to be exceptionally reliable. In fact, in all firings to date Black Knight has never failed to start, and has reached a height of over 500 miles above the Woomera rocket range in Australia.

Since Bristol Siddeley's rocket division began work in 1946 it has developed a wide range of rocket components. By combining these components in single or multi-chamber layouts, thrust requirements from 500 lb up to very high figures, can be met.

BRISTOL SIDDELEY ENGINES LIMITED

Britain's Ballistic Research Vehicle

WITH considerable attention given to news from the other side of the Atlantic of a succession of successful ICBM and satellite launchings interspersed with some spectacular failures, the remarkably satisfactory performance of the Black Knight research missiles at Woomera has largely gone unnoticed. To date five have been launched and all five have achieved what was expected of them.

Readers will recall that news of the first of these came in September, 1958, when the S.B.A.C. Display was coming to a close. At that time practically nothing was made public about the missile—Britain's first ballistic research vehicle—although almost immediately afterwards it was on show to the Press at Farnborough; and more recently, of course, it was publicly displayed at this year's S.B.A.C. Show.

Black Knight's history really goes back to the initial introduction of the long-range ballistic type of guided missile into Britain's weapons development programme. With this inevitably came a requirement for corresponding research equipment for investigating such new problems as would be introduced. This dictated the need for a ballistic test vehicle and at an early stage in the planning for this it was decided that such a vehicle should have a performance comparable with representative missiles, and that it should also be much smaller and less expensive. This would enable tests to be made under more flexible conditions and with greater accuracy than would be possible if a full-sized weapon were used.

Following the general procedure adopted for the earlier R.A.E. guided weapons test vehicles, design studies were made by the Ballistic Missile Division of the Establishment's Guided Weapons Department. From these studies, the choice was finally made of an outline scheme that appeared to offer the best compromise in meeting the somewhat conflicting requirements of performance, flexibility of application, payload carrying capabilities, cost and probable development time.

These last two items made it essential to use, where possible, fairly standard structural and production techniques and to employ either existing components or those which could be readily modified with the minimum of extra development. Under this heading were included control electronics and hydraulic servo components, guidance equipment and rocket engines.

The design which finally emerged closely resembled the version of Black Knight seen at Farnborough this year. Several alternative configurations of this were envisaged and these involved changes forward of the electronics bay front diaphragm only.

An accompanying diagram (p. 571) shows examples of these alternatives. One is a single-stage re-entry vehicle; another is that vehicle adapted to carry a heavy payload of equipment under test; and a third is a two-stage configuration, with a solid-propellent motor used for the second stage, and intended for very high re-entry speeds.

When the basic design study was completed by R.A.E., the project was handed over to the industry for completion. Saunders-Roe, Ltd. was chosen as the main contractor with Armstrong Siddeley Motors (later to become Bristol Siddeley Engines) as the sub-contractor responsible for the powerplant. This was to be a modified and re-engineered version of the Gamma HTP/kerosene unit originally developed by the Rocket Propulsion Establishment at Westcott.

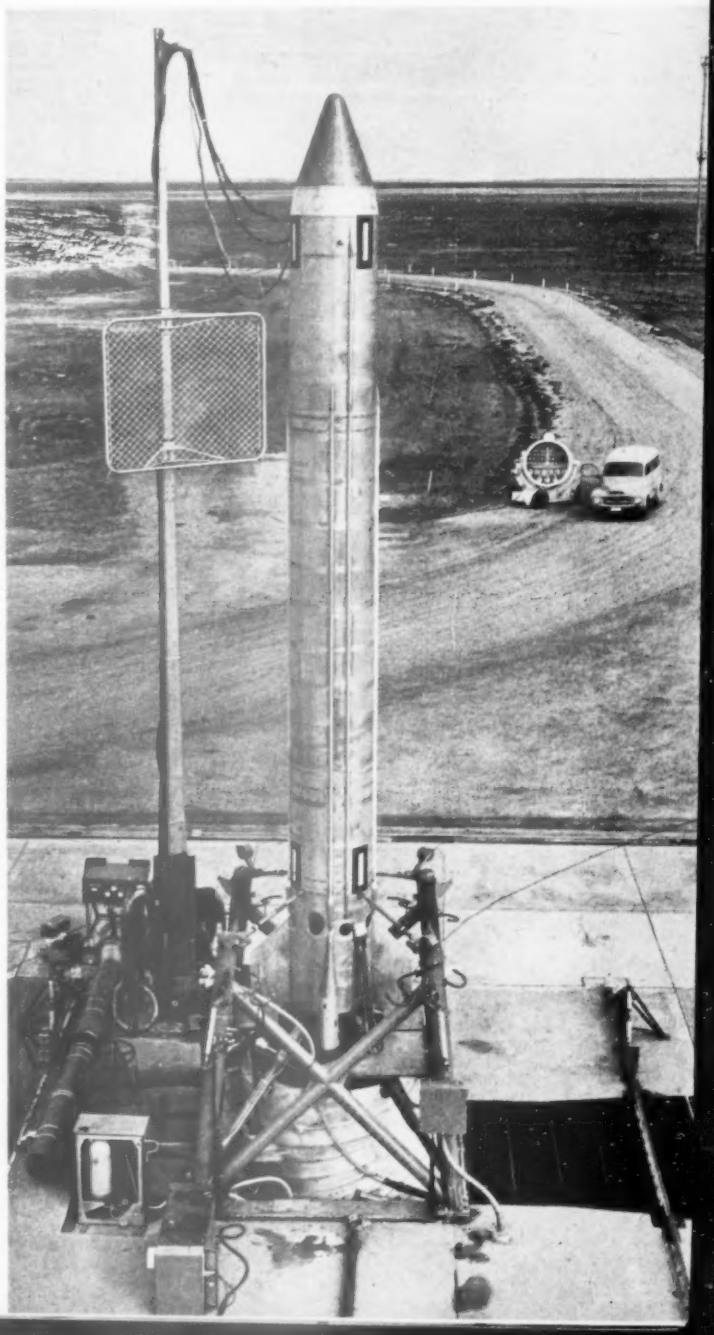
In point of fact, the R.A.E. manages the whole Black Knight project as a design, research and development authority—which responsibility is vested in the Director of the Establishment. Changes in design requirements, trials, planning, development of instrumentation, and general project management are in the hands of the Guided Weapons Department. Such things as guidance and telemetry systems were developed as joint efforts on the part of the R.A.E. Guided Weapons, Radio and Trials Departments.

Detailed design of the vehicle and its systems as well as of the very extensive ground support equipment for it, has been the joint responsibility of Saunders-Roe and R.A.E. The Saro team are also responsible—either directly or through sub-contractors—for the manufacture of the greater part of the vehicle and ground equipment. The company is also the authority for the acceptance testing of the vehicles, to R.A.E. requirements, in this country; this is done at High Down in the Isle of Wight (see THE AEROPLANE for October 10, 1958).

Layout and Structure

Below the nose cone, the cylindrical body of Black Knight is built up with six principal sections. First comes the separation bay, the shape of which can be varied so as to provide a section for the attachment to the missile of either a separating re-entry head, or some other payload portion.

Next there is the electronics bay which houses control system



A Black Knight on the launching pad at Woomera; note the exhaust deflection duct at the base of the stand—it is water-cooled for static firing tests.

electronics, autopilot, guidance electronics, one of the several telemetry transmitters, electrical power supplies, rotary converters, and so on. This section is lagged and provided with cooling and air circulating equipment. Both the electronics bay and the re-entry head are sealed at ground level and both are equipped with vent valves so that appropriate differential pressures are obtained during ascent.

Equipment in the electronics bay is mounted on two sliding trays to facilitate installation and removal. Access to the trays is provided by two removable panels.

A battery pack supplies DC power at various voltages while AC power is obtained through inverters. The batteries are of the silver-zinc type and are suitably housed in glass-fibre boxes.

Prior to firing, the vehicle is supplied with electrical power from an external source. For this, connection is made through two socket assemblies mounted flush with the skin plating of the electronics bay. Electrically controlled ejector plugs are used with these sockets.

Below the electronics bay is the kerosene tank. This is an integral-type tank with the body skin forming its walls. Kerosene is fed to the engine through four pipes carried in glass-fibre shrouds over the HTP tank.

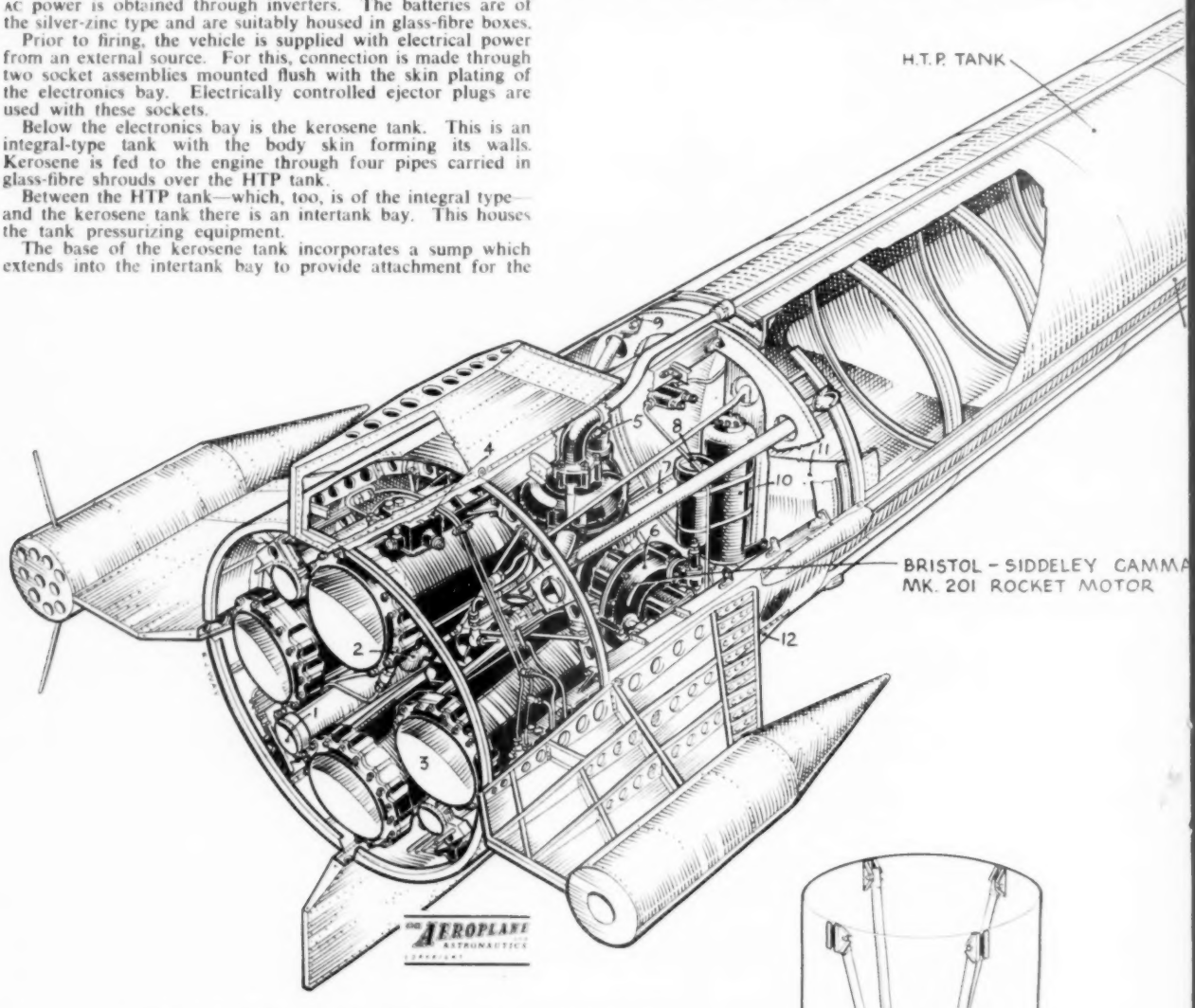
Between the HTP tank—which, too, is of the integral type—and the kerosene tank there is an intertank bay. This houses the tank pressurizing equipment.

The base of the kerosene tank incorporates a sump which extends into the intertank bay to provide attachment for the four main delivery lines. These pipes enter individual shrouds, on the outside of the main body, which extend to the engine bay—beyond which the pipes are shrouded in detachable fairings down to the main fins.

The kerosene tank is sealed at ground level and is fitted with a combined inward and outward vent valve. This valve is located in the electronics bay and the associated pipe line extends to the skin plating where it is vented to the atmosphere.

For the HTP supply, a single steel feed pipe extends downward from the centre of the tank base. A flexible bellows welded to the lower end of the pipe is bolted to a four-way casting, the four arms of which connect with the inlets of the engine's four turbopump units.

The sixth section of Black Knight's main body is the propulsion bay housing the four combustion chambers and turbopumps of the Gamma powerplant. Some instrumentation,

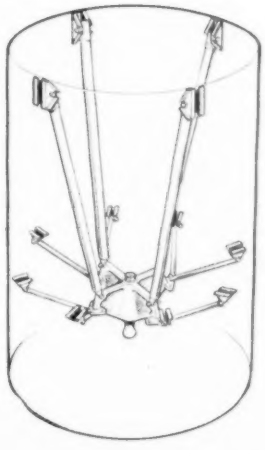


BLACK KNIGHT RE-ENTRY TEST VEHICLE

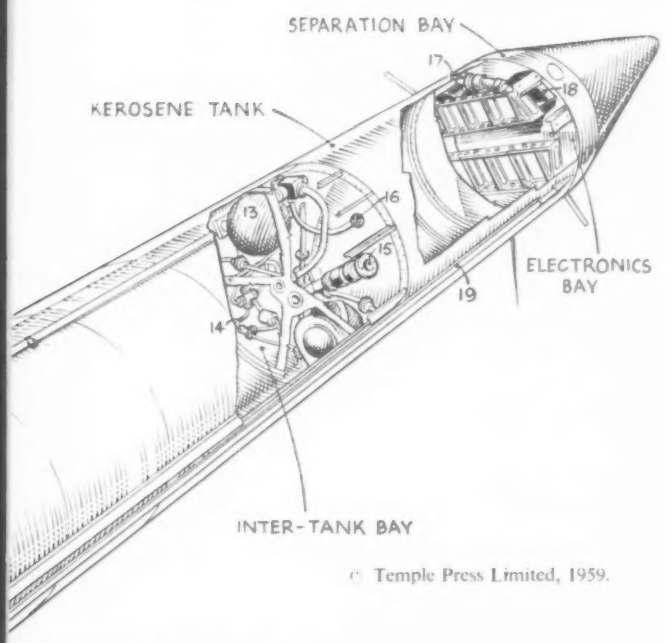
One Gamma HTP/Kerosene rocket engine

1. Turbine exhausts (four).
2. Vehicle support ball.
3. Combustion chamber (four).
4. Servo actuator (four).
5. Steam generator (four).
6. Turbo-pump (four).
7. HTP supply pipe.
8. Hydraulic accumulator.
9. Motor mounting structure.
10. Hydraulic reservoir.
11. HTP tank domed bulkhead.
12. Rip-plug fairing.
13. HTP tank air-pressurizing bottles.
14. Transducer pipes.
15. HTP tank pressure relief valve.
16. Air charging point.
17. Kerosene blow-off valve.
18. Radio command link system equipment.
19. Wiring conduit to electronics bay.

A detailed cut-away drawing of the Bristol Siddeley Gamma was published in THE AEROPLANE AND ASTRONAUTICS for Sept. 4, 1959.



Engine mounting detail.



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4 KEROSENE DELIVERY PIPES

hydraulic servo pumps, hydraulic accumulator and reservoir, and servo actuators are also installed in this section.

The four fins are mounted on the propulsion bay. Two of these fins carry end pods housing certain items of instrumentation and some guidance equipment.

Structurally, Black Knight comprises a comparatively orthodox light-alloy "airframe" with the main body as a built-up shell stiffened by external stringers and partitioned by dished bulkheads to form the two fuel tanks and the two component bays. There are two strengthened frames, one at the base of the HTP tank and the other at the top of the kerosene tank, which function as transport joints.

In the propulsion bay, the primary structural member is a circular main beam assembly by means of which the bay is attached to the main body. This attachment is effected by a bolted ring joint. The rocket engine is supported by four vertical support beams stiffened by intermediate and lower frames. There are also four steel struts which pick up with a centre casting.

The fins are of conventional spar and rib construction and the skin plating is flat as the nose ribs have a straight taper towards the leading-edge. Four fittings carried on the lower frame in the propulsion bay provide the main attachment for the fins and additional location for them is provided by dowels extending from the front spars to engage with holes in the intermediate frame of the propulsion bay.

Control and Stability

Control of Black Knight in pitch and yaw, is effected solely by swivelling the four engine combustion chambers. Each chamber is constrained to swing in one plane only, so that pitch, yaw and roll control are all obtained without the use of additional jets.

The vehicle is inherently unstable aerodynamically throughout most of its flight, and yaw and roll stabilization are maintained by the use of a constant heading autopilot. The vehicle is roll stabilized, rather than roll rate stabilized, to ease the guidance problem.

Deflection of each pair of combustion chambers is by an electro-hydraulic servo mechanism, the oil flow being governed by a Laws relay. This relay is connected to a servo amplifier, the output currents of which are proportional to voltage signals fed into input grid terminals.

Thus the oil flow into the actuator jacks is controlled by an electrical "demand" signal. To complete the inner servo loop, a signal voltage—proportional to the motor angle—is also applied to the input terminals of the servo amplifier to cancel the "demand" signal. An AC pick-off and a demodulator provide the feedback voltage.

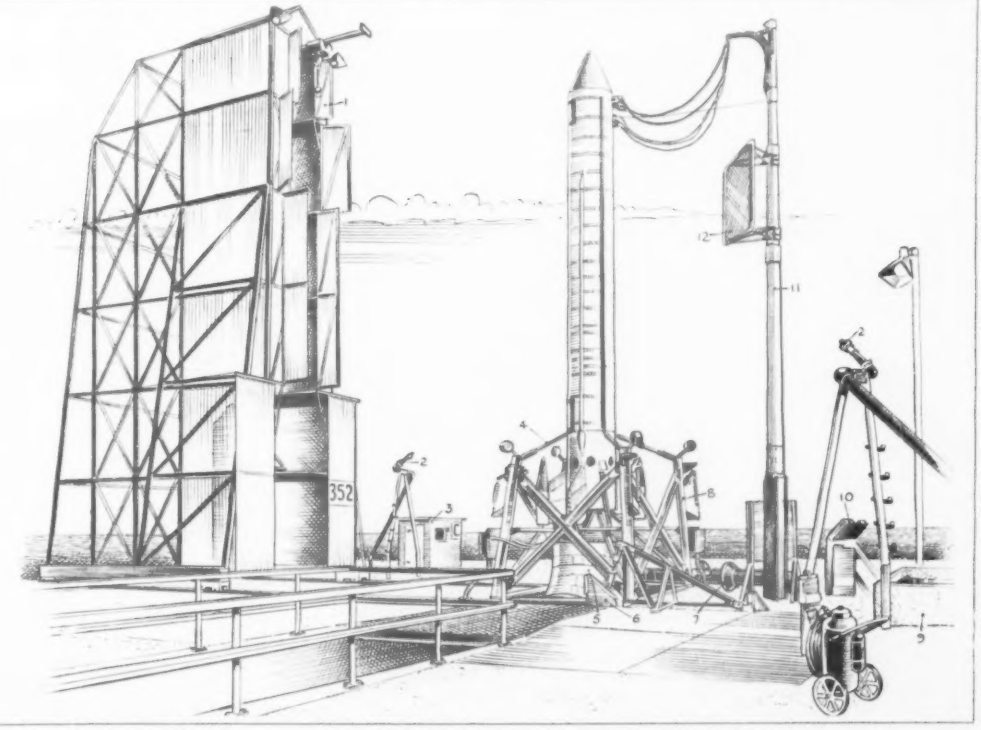
"Demand" signals to the four servo amplifiers are derived from two free gyroscopes. One of these determines the pitch attitude whilst the other determines the yaw and roll attitudes. Any deviation from course is detected by movement of the gyro gimbals and this is converted into a voltage, proportional to the heading angle error, by an AC pick-off and demodulator. This signal voltage results in motor deflection through the electronic network and the associated servo amplifiers.

Provision is made for ground control of Black Knight through a "command link" system. The very high all-burnt velocity of Black Knight, even as a single-stage vehicle, makes displacement from the programmed climb path very significant from the point of view of impact dispersion.

For this reason Black Knight has, in addition to the

GROUND INSTALLATIONS

1. Servicing gantry.
2. Water jets.
3. Test position.
4. Wind-brace arms.
5. Exhaust duct.
6. Gantry stop and lock.
7. Exhaust duct cooling water main.
8. Launching frame, form.
9. Personnel plunge tank (H.T.P. contamination).
10. Cooling-water control panel.
11. Umbilical mast.
12. Plug crash net.



Black Knight is normally fired after dark so as to simplify the tracking of the vehicle which is equipped with a number of light sources for this purpose.

constant heading autopilot, a fairly simple but very effective guidance system. The vehicle, after a vertical climb from the take-off, is turned by command from the ground into its climb path along a fixed datum. It is held there throughout powered flight by radioed commands, as required, from the guidance equipment located in the launcher pad "equipment centre" or "blockhouse" some distance from the launcher.

Fins were used to limit the degree of instability during certain periods of flight in order to ease the bandwidth and power requirements of the chamber-swivelling servo-motors. An optimum was struck between the problems and weight introduced by eliminating fins altogether and using more power and wider bandwidth servo-motors (with larger angles of chamber swing in gust conditions), and the increased structure weight of fins.

In considering control system design, the overall design of the vehicle must be taken into account simultaneously. The fineness ratio of the body, the structural modes in bending and in torsion, the aerodynamic cross-coupling all have to be considered, right at the start, in connection with the design of the control system; and, if necessary, they have to be adjusted to minimize such problems as unstable interaction between body flexure and control torques.

In Black Knight, because of the use of fins, fairly good separation between body modes and servo-frequencies is obtained—aided by considerable shaping of the autopilot error signals. Fuel slosh and variation in missile moments of motion during flight also become important in a vehicle whose all-burnt weight is a small fraction of take-off weight.

As already mentioned the four combustion chambers of the Gamma powerplant are operated by hydraulic servo-actuators supplied from a 3,000-p.s.i. system. Oil is delivered from two pumps driven by the propellent injection turbines. Short duration demands of a transient nature, such as those expected during controlled flight in heavy gusts are dealt with by an air-pressurized piston-type hydraulic accumulator and its reservoir.

For the purpose of ground testing the actuators and associated control system can be operated by means of an external pump. Connection to the portable ground running unit is made through self-sealing couplings mounted on the structure within the propulsion bay. Access to the couplings is by way of removable panels on the outer skin.

Ground Equipment

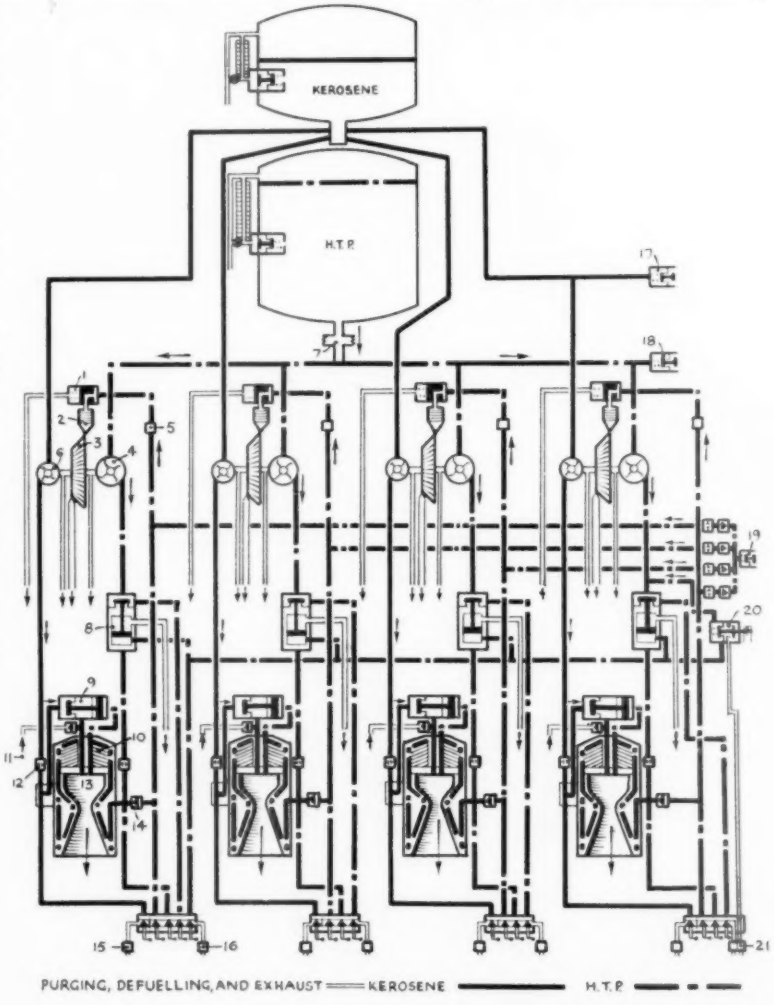
In the design, development and operation of ballistic missiles, ground equipment becomes a major item on the score of cost and effort. Because of its size, rather than weight, such operations as transport of the vehicle to the range, pre-launcher testing and erection in the launcher, demand considerable handling equipment. In this Black Knight is no exception.

The vehicle is erected on the launcher—from which it is fired vertically—by means of a hoist and guides in the gantry. This gantry allows access to the various levels of the vehicle during the final test phases, and protects it from the desert environment prior to launching. After final preparation, the gantry can be driven back on rails from the launcher for fuelling and launching.

In the launcher the vehicle is held on a point support at its base. This is on the centre-line between the four combustion chambers and is in the form of a ball socketed into a release jack on the launcher stand.

Adjustable lateral "steadies" hold the vehicle vertical. The rocket efflux gases pass into a water-cooled deflector duct designed for both launching and full-duration static firing conditions.

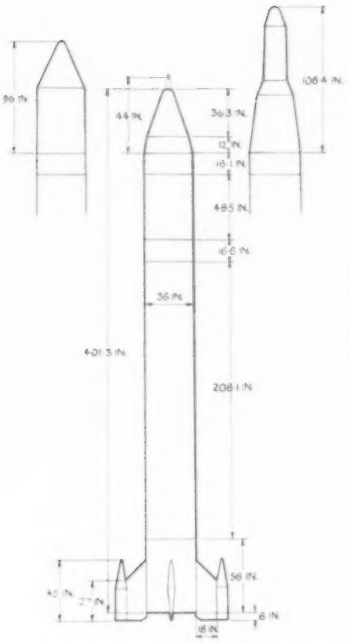
Associated with the launcher is a nearby "test post" where electrical priming and other supplies are located and monitoring



The complete propellent system for the four combustion chambers of the vehicle's Gamma rocket engine. This diagram also shows the arrangements made for purging and defuelling the system.

KEY

1—control valve; 2—steam generating catalyst; 3—Turbo-pump; 4—HTP pump; 5—filter; 6—kerosene pump; 7—expansion bellows; 8—main HTP valve; 9—kerosene valve; 10—combustion chamber catalyst; 11—nitrogen purging inlet; 12—kerosene orifice; 13—combustion chamber; 14—non-return valve; 15—kerosene defuelling valve; 16—HTP (3 or 4 way) defuelling valves; 17—kerosene refuelling/defuelling valve; 18—HTP refuelling/defuelling valve; 19—HTP ground starting valve; 20—solenoid valve; 21—air supply connection.



Three versions of Black Knight. Left, a "heavy payload" head; centre, the standard re-entry test vehicle; right, a two-stage head for very high speed re-entry tests.

cables terminated. Connection to the vehicle is made through "rip plugs" located around the propulsion bay and by umbilical cables plugging into the forward part of the vehicle.

Control of vehicle and launcher systems is accomplished from a heavily constructed control building known as the "equipment centre." This is located several hundred yards from the launcher and contains vehicle monitoring consoles, telemetry monitors, recorders, local sequencing equipment and guidance equipment.

In the later stages of the firing sequence the monitoring of a number of the functions of the vehicle demands a speed and accuracy greater than can reasonably be expected of a human operator. For this reason the final phase of the sequence during which the majority of the operations occur is completely automatic.

A number of quantities or operations are linked into the time sequence in the form of acceptable limits. Each of the limits must be met before the sequence proceeds, or automatic stop action occurs. In addition, "manual" stop action may be invoked during the automatic phase—or before, if any display quantities—usually steady or slowly varying—fall outside the limits (e.g., electrical supply voltages).

The final operation in the sequence is to release the vehicle via the "release jack" and hold-down point. The vehicle is not released until, for example, the engine is developing correct thrust, the control hydraulics and electronics are satisfactory; and the ground supply plugs are ejected. This system ensures that the vehicle is performing adequately when it is released from the launcher.

Data on vehicle performance are derived largely from radio telemetry, using a modified form of the R.A.E.'s sub-miniature telemetry equipment with long range and increased channel handling capacity. This is supplemented, where necessary, with missile-borne tape recording equipment, made robust enough to withstand very heavy ground impacts. This system relies, of course, on recovery of the vehicle or parts of it.

A great deal of effort has been expended in developing and measuring equipment for use with telemetry and tape recorders. To reduce weight, size and power supplies, transistors are extensively used; they have, in fact, been virtually indispensable in this project because of the enormous significance of weight.

Vehicles are at present fired at night. The extremely good visibility obtainable at Woomera enables trajectory and other measurements to be heavily augmented by optical observations. At the great ranges involved in Black Knight these are best done at night, relying on light sources of several kinds incorporated in the vehicle.

Black Knight is a truly joint effort—the Royal Aircraft Establishment, the Rocket Propulsion Establishment, Saunders-Roe, Bristol Siddeley Engines, and a host of suppliers of equipment and materials have had a hand in its production. They certainly have every reason to be satisfied with the results of their efforts for not only has the vehicle "worked" unusually well, it is providing a wealth of invaluable information on many aspects of ballistic missile technology.

Propulsion for Black Knight

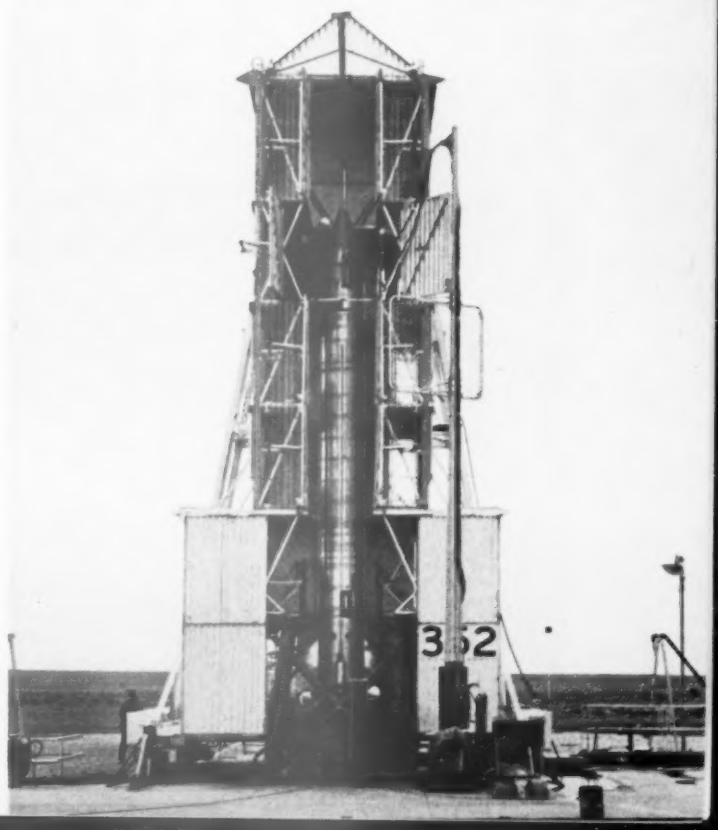
ALTHOUGH it might be said that the overall performance of any guided missile or corresponding test vehicle is governed by the efficient working of a complex of electronic devices, it is equally true to say that its success is primarily dependent on having a reliable and efficient powerplant. This is a particularly valid claim in the case of the longer-range ballistic missiles for which the engine is expected to operate for a somewhat longer period than in the case of other missiles. In this respect, a good share of the credit for Black Knight's success must go to the Bristol Siddeley (previously Armstrong Siddeley) team at Coventry, responsible for the design and subsequent development of the Gamma rocket engine for it.

As mentioned earlier, this has been derived from the HTP/kerosene engine of the same name originally designed and built by the R.A.E.'s rocket propulsion department—now the Rocket Propulsion Establishment—at Westcott. Its development history, in fact, really goes back to 1951 when R.A.E. started work on a rocket engine for the then proposed mixed-powerplant interceptor fighter.

This work was initiated as an "insurance" effort complementing the Screamer and Spectre rocket engines being designed by Armstrong Siddeley and de Havilland respectively to meet the official specification for this fighter—which subsequently came into being as the Saunders-Roe S-R.53 with a Viper/Spectre powerplant. The initial requirement was for a liquid rocket unit delivering a thrust of 7,000 lb. and capable of being throttled to 10% of the max. thrust.

The first layout studied by R.P.D. was for a single-chamber engine but this was subsequently abandoned because the low combustion efficiency made the throttling requirement difficult to meet. A two-chamber engine was then decided upon; in this, one chamber was to give two-thirds of the thrust and the other one-third, to cater for the cruising case.

Design on these lines proceeded but complications associated with having two chambers of unequal size were inevitably



Prior to firing, the vehicle is enclosed in this "gantry" which gives access to Black Knight at various levels.

introduced and it was eventually considered that the advantage to be gained from such a layout did not justify the amount of work involved.

It was then decided to have two equal-thrust units—each developing 4,000 lb. as the total thrust requirement had by this time been raised from 7,000 lb. to 8,000 lb. Each chamber was to be provided with a turbopump unit driving an HTP and a kerosene pump. This twin-chamber unit, with each portion capable of being throttled down to 20% of its maximum thrust, formed the final arrangement on which development was started.

In 1953 work on a half-unit—that is one chamber and one turbopump—began and its components were tested individually later the same year. The first complete 4,000-lb. single-chamber engine with turbopump and control valves was run for the first time in 1955. A year later the first 8,000-lb. double unit was run on the test bed; it was known at R.P.D. as the Gamma engine.

Early in 1955, the R.A.E. asked the rocket team at Westcott to investigate the possibilities for a powerplant for the proposed Black Knight re-entry test vehicle. All the available engines—Spectre, Screamer, Scorpion and Gamma—were studied.

The requirement was for a total sea-level thrust of 16,000 lb. with a gimballed combustion chamber for missile control. Low weight was given as a prime consideration.

After much consideration of all the factors involved Gamma was the basic powerplant decided upon. Even so, its use in Black Knight demanded a number of significant changes from the R.P.D.'s original design. For example, provision had to be made for the combustion chamber to be gimballed; and improvement of the burners and the specific impulse was also necessary.

Thus when the Armstrong Siddeley team were given the task of producing the powerplant for Black Knight, they had to do a considerable amount of new design and re-engineering of the basic R.P.D. unit before it could be built. This was, in fact, undertaken as a sub-contract from Saunders-Roe as the main contractor for the Black Knight production programme.

A firm requirement of the arrangement, however, was that the basic features of the original R.P.D. Gamma, which had been proven on the test bed, should remain unaltered. Within that broad boundary the company was free to make any necessary changes or refinements—provided that their precise effects could be estimated in advance and that they would not necessitate extensive development. On this basis the work of producing a powerplant for Black Knight proceeded.

One of the principal problems was to arrange for the swivelling combustion chambers. To give the required directional control of the vehicle, two diametrically opposite chambers are swivelled together in the same direction for, say, pitch control; and the other two are likewise moved together for yaw control. As Black Knight is intended to be roll stabilized all four chambers are moved in the same direction to counteract any tendency to roll.

With the combustion chambers mounted on trunnions and actuated by hydraulic jacks, it was decided to avoid using flexible pipes for carrying the HTP and kerosene to the burners by ducting the propellants through the trunnions and using rigid pipes. Thus the HTP line is led to the inboard trunnion whence it is ducted to the outer shell of the combustion chamber, round which it circulates for cooling purposes before being fed to the catalyst pack. The kerosene is likewise taken to the outboard trunnion and is ducted straight to the combustion chamber as soon as the HTP has decomposed.

One of the noteworthy features of the Gamma engine is the safety system devised by the Bristol Siddeley team to prevent HTP from entering the fuel line before combustion in the chamber is initiated. With a single-point kerosene injection system this is easily achieved by means of a shut-off valve. In the case of the Gamma, however, a multiple-point burner was introduced in order to improve combustion efficiency and clearly it is not possible to have a shut-off valve at each point.

The rocket design team at Coventry therefore developed a nitrogen blast system in which nitrogen at a constant pressure is fed into the fuel inlet through a non-return valve. The pressure is greater than the engine's "cold" running pressure, when only HTP is being decomposed, but is less than the fuel delivery pressure. Thus no decomposed HTP can get back into the fuel line and there is no restriction on the flow of fuel into the chamber.

As this safety precaution is only needed during the starting sequence, there is no need for the nitrogen supply to be considered part of the engine's ancillary systems. Thus the nitrogen is made available from a ground installation which is disconnected automatically as soon as the vehicle rises from the launching pad.

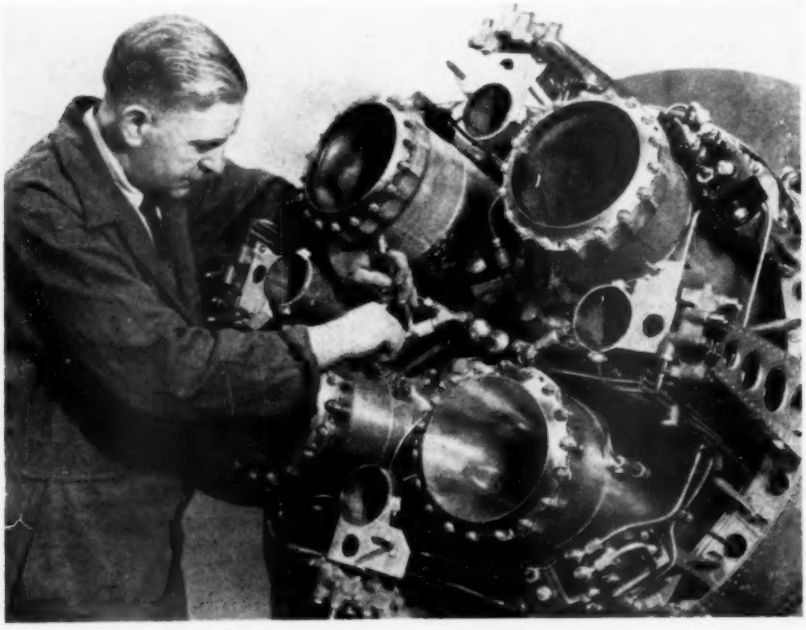
The turbopump used in the production-type Gamma is basically the same as that designed by the R.P.D. at Westcott. There have, however, been some important local modifications to these units. For example, on the kerosene side of the pump a ball bearing is now used in place of the original rod bearing which cannot take end load—and this, it was found, was being developed by the pump.

As already mentioned each combustion chamber has its own turbopump. These four units are assembled in the form of a cross with the joint being made by a common HTP manifold. Each has an HTP and kerosene pump impeller at opposite ends of the shaft carrying the axial-flow power turbine.

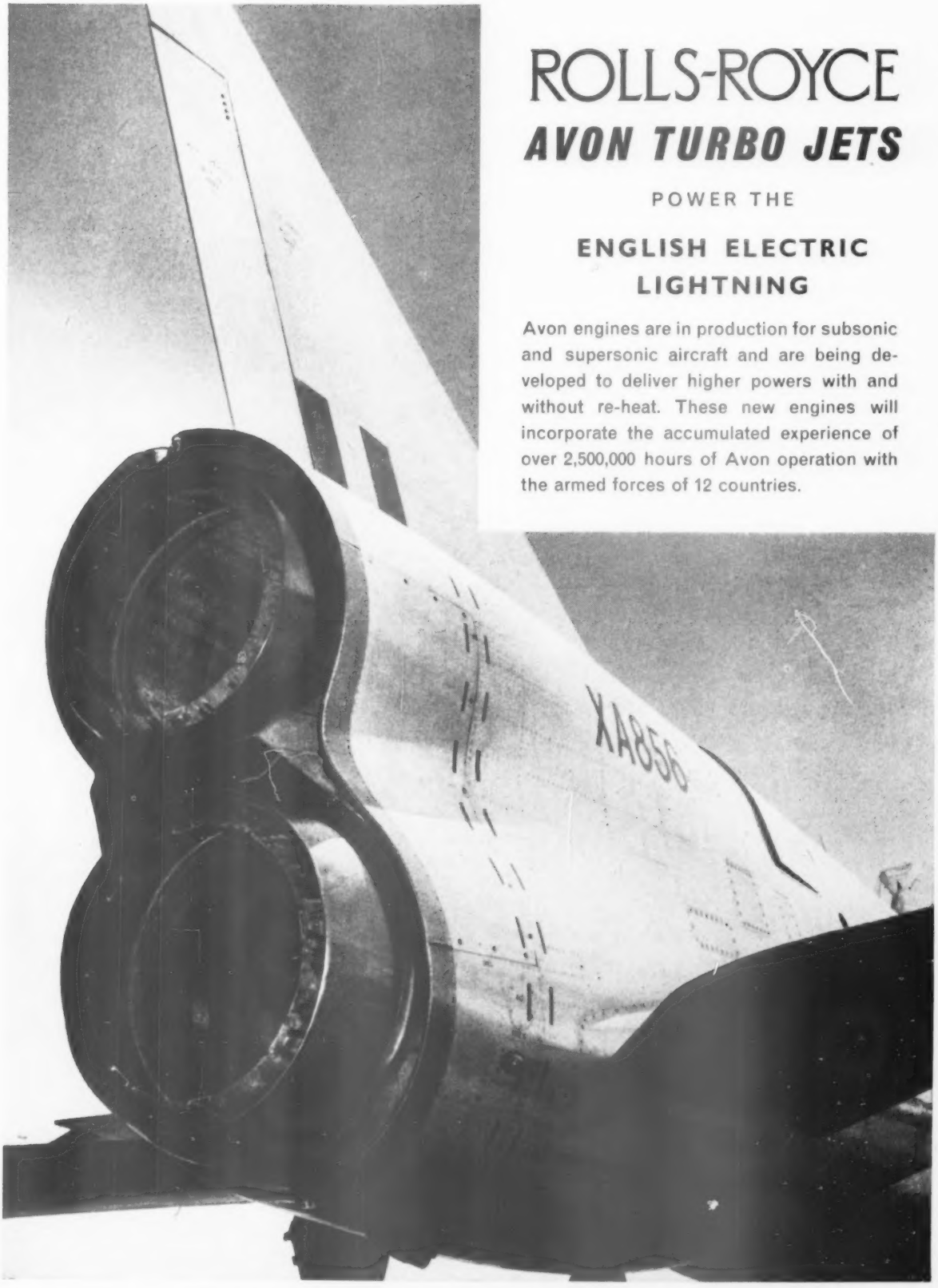
This turbine is driven by HTP from the normal propellent system and decomposed in a separate catalyst pack. For the starting phase, before the turbopumps are operative, HTP is supplied under pressure from an external source which is automatically disconnected at launching—by which time the delivery from the engine's own HTP pumps is available to supply the turbine catalyst as well as the main burners.

As hydraulic actuators are used for operating the gimballed combustion chambers, a supply of hydraulic fluid under pressure had to be made available in the redesigned engine. This was accomplished by incorporating two gear pumps driven from two of the four main turbopump drive-shafts. These gear pumps have been designed to run fully immersed in kerosene, for cooling purposes.

It says much for the efforts of the team at Coventry that the first four-chamber Gamma was completed by October, 1956. The engine passed a type clearance test exactly a year later and on September 7, 1958, the first launching took place from Woomera. Since that date four others have succeeded in their appointed propulsion task; and even more have completed a great deal of test bed running from which has been amassed a wealth of experience and information on HTP/kerosene rocket powerplants generally.



This close-up of the Gamma combustion chambers shows their general layout in relation to the support ball, which is held by a release jack on the launcher stand.



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Northrop N-156F Fighter

The first part of a design critique by our U.S.A. Correspondent, STANLEY H. EVANS, F.R.Ae.S., A.F.I.Ae.S., *on an American solution for a low-cost, lightweight fighter for NATO, SEATO, CENTO and allied air forces.*

NORTHROP International lived up to its nascent name last May, when its Norair Division at Hawthorne rolled out the N-156F twin-jetted fighter before a colourful international assembly of military air attachés and Press scribes, and a representative segment of the skilled artisans who built the job. It was a nice democratic touch, we thought, to include these N.I.P.s (Non-Important Persons) along with the V.I.P.s and the High Brass; but, for some odd reason, the designers and technicians responsible for the creative side of this conspicuous exhibit in aircraft design imagineering were conspicuous by their absence. Actually, it was a national holiday, so perhaps they were trying to forget the PACE* of things at Northrop for a change of pace at the nearby beaches and mountains.

In sharp contrast to this scarcity of the engineering élite, there was an unusually large admixture of smiling Japanese gentlemen industriously engaged in noting and photographing "the works" from the outside on in. We stood right behind one of them while he ran off a ciné film on the engine air intake and ducting. The pictorial result could hardly be glamorous but, technically (we mused), it might be highly rewarding, for this is one of those sensitive areas of the supersonic flow art which undoubtedly accounted for a large proportion of the 7,000-plus hours of model research expended to date on the N-156F and its T-38 Talon two-seater trainer variant briefly described in THE AEROPLANE AND ASTRONAUTICS, May 15, 1959.

Both these types, which are currently powered with twin General Electric YJ85-1 non-afterburning turbojets rated at 2,100 lb. s.t., are now clocking up the test hours at Edwards in the hands of Northrop, U.S.A.F. and other allied test pilots. Installation of the higher powered G.E. J85-5 afterburning engines, rated at 2,500 lb. s.t. (dry) and 3,850 lb. s.t. (a/b), is scheduled for late December or early January, 1960.

* (Note.—PACE at Northrop stands for "Performance and Cost Evaluation," a form of motion-time study controlled by a pacer, a gentleman with a stop-watch, who scouts around the drawing-boards timing, amongst other things, the loss of work efficiency involved in those titillating tête-à-tête that are the mainspring of all good draftsmen the world over. In the long run, the pacer is always outwitted because design engineers are by nature and profession an artfully inventive breed. Eventually, of course, the pacers themselves are returned to more productive pursuits—and morale in the Engineering Dept. settles back once more to normal. "REQUIESCAT IN PACE," as the Romans would have rendered it!)

Design Genetics

Northrop's hymn of praise in selling the N-156 design family in the international market is "Security with Solvency." This old-fashioned theme has some old-fashioned virtues, but the facets of engineering design have this in common with the facts of life—virtues generally come in a mixed package with some accompanying vices. Cut down the aircraft gross weight by chopping away at the weight-growth gremlins at the drawing layout stage and you save costs all down the line—in the factory, in the field, and in flight. But, like all good things, it can be carried past the optimum, and while this observer has always subscribed to the basic Barnwellian fighter concept of the greatest available power boost packaged into the smallest feasible airframe, he was long ago weaned away from what might be called the featherweight fighter with inadequate performance and offensive power.

To overcome these inadequacies a high-boost afterburning turbojet propulsion system must be matched *ab initio* to the aerodynamic configuration and it soon becomes apparent (from the fuel tankage requirement alone) that the gross weight is unlikely to fall below the 10,000 lb. budget. At this point it might be remarked that in the basic "clean fighter" condition—with two air-to-air missiles, but without external fuel tanks—the N-156F is in the 12,000-lb. class, which is still less than half the gross weight of most of the current U.S. Navy and Air Force supersonic fighters. A look at a size comparison of the N-156F and the North American F-100 Super-Sabre (Fig. 1) throws into focus the weight-growth factor in a graphic manner. It also clearly foreshadows the relative cost factor, which will be expanded later under "Money Engineering." Later still, in Part 2, we shall see the performance pay-off of small size and low weight, when allied with the rapid rise of power with increasing Mach No. due to thrust augmentation devices.

One is also inclined to be wary of the modern American fighter trend toward the miniscule-winged manned missile concept with phenomenal air performance, but also with the accompanying vice of lethal ground handling characteristics arising from excessively high approach speeds and sink rates.

Fig. 1. Size Comparison: Northrop N-156F vs. North American F-100 Super-Sabre. Noteworthy also is the trend back towards lesser sweepback of wing and tail surfaces.

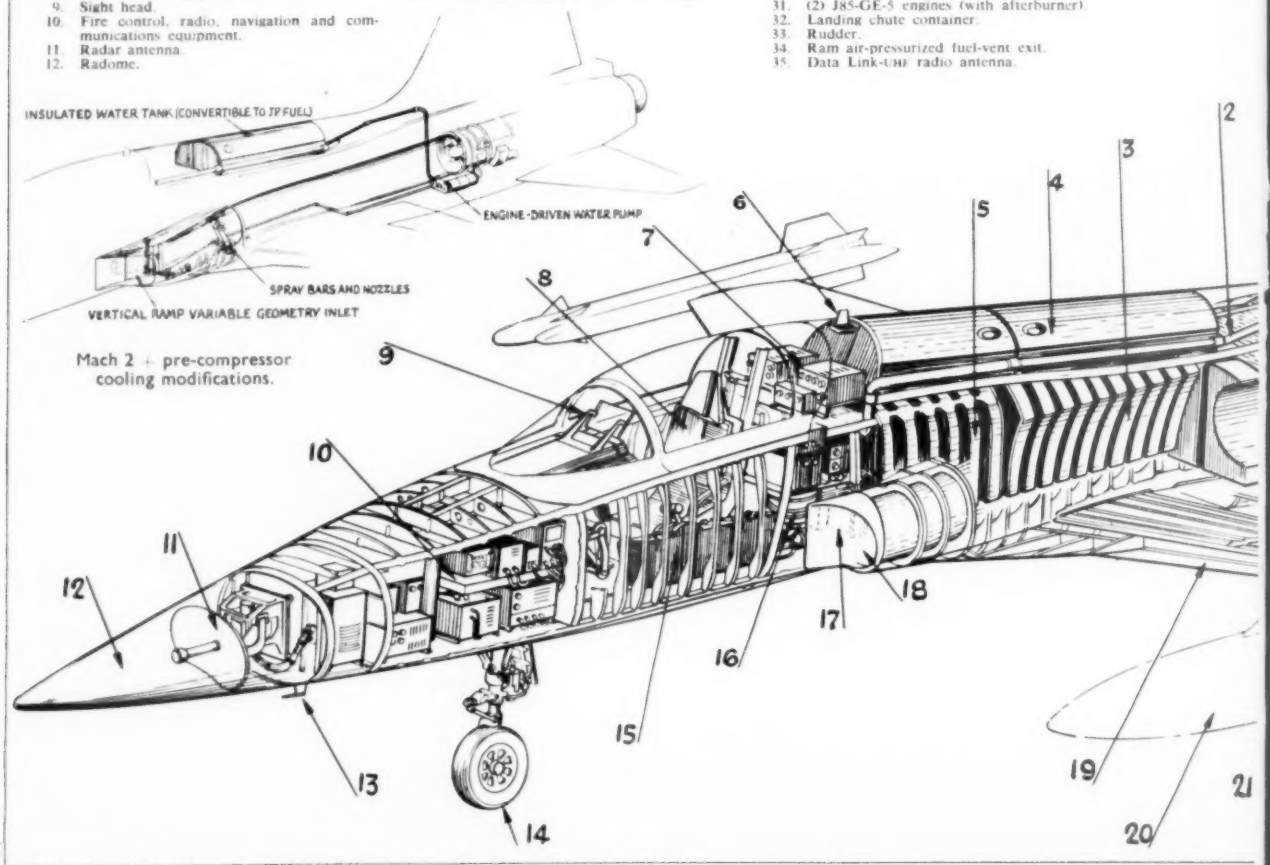
Moreover, the arrow-shaped type of swept-back wing can be doubly unforgiving in this respect. One has only to study the accident statistics of some of the U.S.A.F.'s century series fighters to question the wisdom of stretching take-off wing loadings to well over 200 lb./sq. ft., especially so in the case of single-engined aircraft. Thus, for example, the Lockheed F-104A Starfighter, which started with a normal gross weight of around 17,000 lb. allied to a net effective wing area of only some 120 sq. ft., has now been brought up to an overload take-off weight of 27,000 lb. in the latest F-104G model for the West German Air Force.

The design philosophy, though not the actual design configuration, of the N-156 family goes back to May, 1953, in the shape of a Northrop design proposal for a single-seat, high-altitude supersonic fighter, under the company appellation of "Fang" or N-109 project. By the time the very realistic mock-up was completed in September of that year, the Fang project had assumed the form of a thin (5%) shoulder-winged delta with low-set horizontal tail and swept-back vertical tail. Powerplant was to have been either an Armstrong Siddeley J65 or a General Electric J79 turbojet mounted below, but faired into, the primary fuselage structure, with the lips of the ventral air intake immediately below the pilot's cockpit. Probably as an outcome of the Korean War, the Fang was intended as a well-armed lightweight riposte to the MiG 15. Lightweight in this case meant in the 15-18,000 lb. class, with a modest initial wing loading of 55 lb./sq. ft. A top speed of Mach 2 and a maximum zoom ceiling of at least 70,000 ft. were expected of the higher powered J79 installation.

During this same year, however, and acting under similar wartime pressure, the Lockheed design hierarchy had gone into high-speed action as a result of a visit to the Korean area and discussions with the U.S.A.F. Studies were made to see

Key

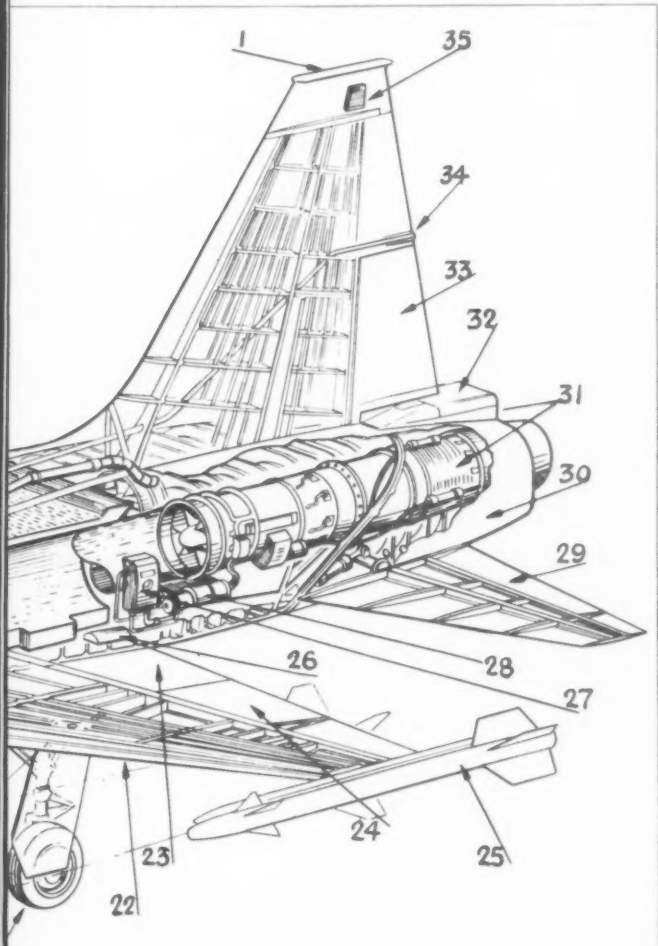
1. Localizer-glide slope antenna.
2. Cabin air-conditioning line.
3. Aft fuselage tank.
4. Dorsal tank.
5. Forward fuselage tank.
6. IFF antenna.
7. Electrical equipment.
8. Upward-ejecting pilot's seat.
9. Sight head.
10. Fire control, radio, navigation and communications equipment.
11. Radar antenna.
12. Radome.
13. Data link-UHF radio antenna and pitot tube.
14. Nose landing gear (18 x 4.4 tyre).
15. Cockpit console.
16. Liquid oxygen converter.
17. Cabin air-conditioning package.
18. Engine air inlet.
19. Leading-edge flap.
20. 200-gal. external fuel tank.
21. L.H. main landing gear (20 x 6.0 tyre).
22. 32° swept leading-edge flap.
23. Flap.
24. Aileron.
25. "Sidewinder" air-to-air missile on launch rail.
26. Marker beacon.
27. Hydraulic reservoir.
28. Airframe-mounted accessory gearbox.
29. All-movable horizontal stabilizer.
30. Removable aft fuselage.
31. (2) J85-GE-5 engines (with afterburner).
32. Landing chute container.
33. Rudder.
34. Ram air-pressurized fuel-vent exit.
35. Data Link-UHF radio antenna.


INSULATED WATER TANK (CONVERTIBLE TO TP FUEL)
ENGINE-DRIVEN WATER PUMP
SPRAY BARS AND NOZZLES
VERTICAL RAMP VARIABLE GEOMETRY INLET
Mach 2 + pre-compressor cooling modifications.

whether or not a fighter in the 15-18,000 lb. gross weight class could be designed which would have high enough performance and satisfactory armament and equipment to stand on its own against fighters of approximately twice that weight category. The outcome of this creative activity is now well known, resulting in the prototype XF-104 with the J65 Sapphire engine, and the production F-104A with the J79 yielding a top Mach No. approaching 2.2 (1,450 m.p.h. at 36,000 ft.). Perhaps even more remarkable than the aircraft's performance was the truly astonishing performance of Lockheed's "Special Project" team under Kelly Johnson: starting in March, 1953, the XF-104 was designed, built and flown in 355 days; moreover, during this period, extensive model tests were run by Lockheed and the N.A.C.A.

The more concrete design concept of the N-156 family evolved from studies conducted by a top Northrop managerial-technical team early in 1954. Discussions at that time, with many of the men responsible in their respective countries for the defence of the NATO and SEATO powers, disclosed a growing concern about the rising cost of weapon systems, and the difficulty of maintaining in the field the complex equipment then becoming available through U.S. aid to its allies in Europe and Asia. The level of total force effectiveness itself was threatened by the problem of providing ever higher performance within available budgets. Anyone who has had the opportunity of closely scrutinizing many of the U.S.A.F. century series fighters will recognize some flagrant examples of this complexity complex.

A case in point that illustrates this in a most striking manner can be viewed at the tail end of the North American F-100 Super-Sabre, where the drogue parachute is boxed flush below the tail-pipe instead of being housed in the more usual and logical place on top of the fuselage stern near the base of the rudder. The chute lanyard, however, is anchored topside and is then carried around one side of the fuselage and housed inside a peripheral series of hinged trap-doors, such that when the chute is released the lanyard unwinds itself from this weird collection of jack-in-the-boxes. The whole mousetrap contraption is a marvel of misplaced mechanical ingenuity and doubtless the designer of it had a field day on the board—and so must the maintenance mechanic in the field. The weight-cost-time factor involved in such toy-like solutions must be quite prohibitive in relation to the function performed. Bearing in mind the many mods to the F-100's vertical tail configuration, it would seem a fair assumption that some bright young aerodynamicist forced the hand of the mechanician to box his chute well away from the rudder and its temperamental airflow.



NORTHROP N-156F MULTI-PURPOSE FIGHTER

The result of the Northrop refresher course in the state of the military design art disclosed at that time (1954) two significant advances outside the realm of the airframe designer that could be exploited by the latter to overcome the size, weight and cost hurdles. These were: (1) new, high thrust/weight ratio, small-diameter turbojets in the 2,000 lb. s.t. (dry) class; and (2) new long-range, high-speed, very intelligent air-to-air missiles which permit the aircraft to fire from much greater distances and from altitudes both below and above their targets. In mating these two promising technologies and then shaping them into the aerodynamic envelope, the Northrop design team under the overall direction of its chief weapon system designer, Welko E. Gasich, really added that third dimension which distinguishes an advance in design from a routine product.

While occasionally it may be disputed in other sections of the design arena, it is not difficult to demonstrate why the aerodynamic side of design plays this dominant, esoteric rôle in the design process, despite the probability that it represents not much more than 5% of the total design effort in terms of engineering man-hours per prototype. The judicious blend of art and science which we know as aerodynamics is, in truth, the "aero" constituent in the aeroplane considered as a moving vehicle in flight; the rest of the design—structural, mechanical, electrical, hydraulic and so on—has the genetics common to other forms of engineering. But unless this aerodynamic 5% be artfully blended (without too heavy a dose of that drowsy medicine labelled "compromise"), the major 95% of the engineering design is so much wasted effort, the end result being just "another aeroplane" ranging from the mediocre to the outright flop.

It can also be put another way: what the designer sees in his mind's eye as the physical shape of things to come is also the aerodynamic form seen, or rather felt, by the air particles as they are smoothly pushed or pressured out of the way; or buffeted and bewildered in turbulent disarray. Smoothly blended, and the first and most important step towards an advance in the art is assured. Poorly imagined and crudely fashioned (in the aerodynamic sense), and we see another routine product come through the mill, however ingeniously contrived the rest of the design may be. For the truth of this, one has only to look around at the contemporary scene and note that four aircraft designs out of five are more notable for the ingenuity of their internal anatomy than their purity of line or "aerodynamic styling." Suffice it to say at this point that the aircraft under review falls within the category of the more shapely minority. But, in addition to aerodynamic elegance, such functional criteria as simplicity, maintainability, producibility, and twin-engine safety and reliability are all built-in features of the N-156F. As a bisonic design exercise it is attractive to the probing mind and to the practised eye.

Although Northrop's first specific application of the N-156 family was the N-156F single-seat fighter version, actually the first contracted programme was for the N-156T two-seat supersonic trainer now being manufactured (as the T-38 Talon) under a production contract for the U.S.A.F. Air Training Command. This was the result of a General Operational Requirement issued in May, 1955, for a supersonic basic trainer

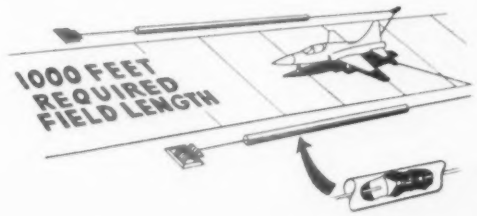
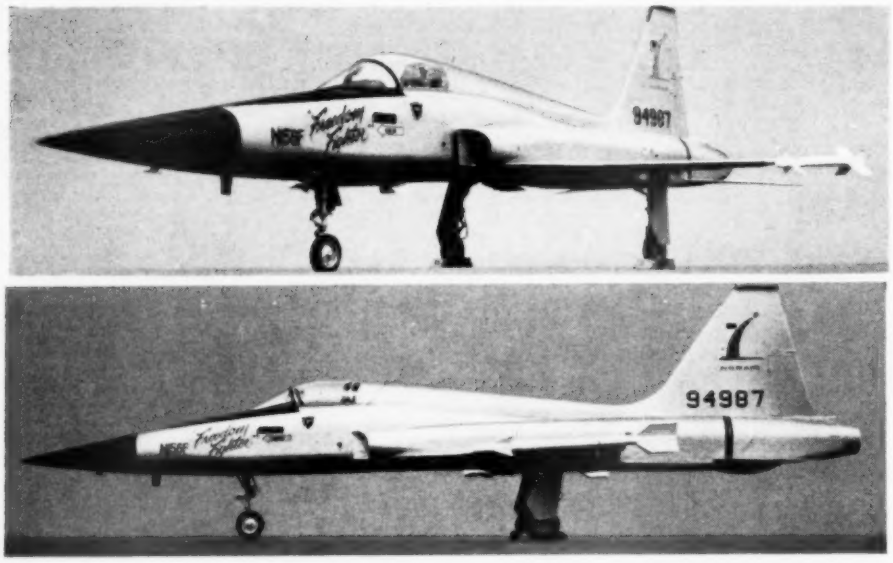


Fig. 4.—Liquid Squeezer Arresting System: This enables the N-156F to use extremely short fields, reducing the landing run to 1,000 ft. Four aircraft per minute can be accommodated.



SUBTLE AERODYNAMICS.—Area-rule styling is evident in these views of the N-156F, which has its two General Electric J85 engines mounted side-by-side in the rear fuselage. Sidewinder AAMs are attached at the wing-tips. Note the end plate at the tip of the fin.

support system intended to replace the Lockheed T-33 subsonic jet trainer. Actually, while the T-38 was in the design and production stage, the N-156F design and model testing proceeded in parallel with it under a U.S.A.F. $7 million development contract for three flight tests and one static test prototype aircraft, their manufacture following by some six months or so. Apart from the different fore-body and tandem seat layout of the trainer, and the addition of wing leading-edge flaps and larger horizontal tail of the fighter, both design configurations are basically the same with approximately 80% of their components interchangeable.

Design Criteria

Having broadly traced the N-156F's lineage we can draw up the following criteria as the basis for the design specification: (1) Simplicity. (2) Maintainability. (3) Producibility. (4) Safety and Reliability (based on twin abreast engines). (5) Low Cost (from small size and light weight). (6) High Performance (Mach 2-plus capability without sacrifice of pilot handling qualities). The birth-pangs of this creative process have been clearly visualized by Northrop as follows:—

It was the purpose of these design criteria to formulate specific requirements which would control the overall design philosophy. The basic requirement conformed with the corporate objective of maximum performance combined with sophisticated control and stability characteristics in flight and safe handling at take-off and landing—all this at the lowest possible cost. This would be implemented by the use of the latest technology (or "state of the art") to attain simplicity rather than the complexity which is dominating weapon system designs today.

Of paramount importance was the criterion that the aircraft could be easily maintained. The maintainability aspects, therefore, were given special consideration in all primary features of the overall configuration and were emphasized on an equal basis with performance. This requirement for maintainability almost automatically leads to the criterion of ease of producibility. Since it was considered that large numbers of this type of aircraft (N-156F, T-38, a possible shipborne variant, etc.) would be produced, tooling and manufacturing personnel were brought into service during the preliminary design stages to ensure application of modern production methods.

Although flight safety is a basic requirement to be applied to the development of any piloted aircraft, it is particularly applicable to a supersonic fighter and calls for strict adherence to safety considerations throughout the design. This consideration for flight safety had a strong influence on the aircraft configuration and led indirectly to the establishment of aerodynamic design criteria that would dictate not only first-class flying qualities, but more acceptable take-off and landing characteristics than those of contemporary supersonic fighters.

The application of strong policies in regard to the structural and component design are necessary to fulfil the objectives of minimum weight. Implementation of these policies made it mandatory to exploit to the maximum such fabrication techniques as machined and/or chemi-milled skins, sandwich construction, and the elimination of unnecessary structural splices. In addition, specified design criteria (military as well as company) were critically examined to avoid any unnecessary conservatism in loading, rigidity, smoothness, and deflection requirements. To ensure that the entire structure would possess no excessive margins of safety, structural design was predicated on the assumption that the static test programme would complement optimistic analyses to attain full required strength, yet eliminate undue conservatism.

The approach toward weight economy in the design of subsystems was based upon utilization of the absolute minimum number and size of components necessary to meet the functional requirements of the aircraft. It is pointed out here that one item of unnecessary equipment may well add more weight than can be saved by extremely careful design of an entire structural sub-assembly. Safety can never be overlooked and no system or component having a high probability of failure which could cause loss of life can be tolerated. However, in attempting to provide safety for combinations of conditions which are highly improbable, or for the worst cases of somewhat unknown requirements, systems can become unduly complicated. Such complexity may actually result in a less safe aircraft.

A typical example of the discrete choice of components as practised in the N-156F and T-38 designs is the elimination of a ram air turbine for emergency hydraulic and electric power. Instead, "designed-in" safety is provided by the employment of two independent hydraulic and electrical systems, each powered by one of the two engines, and a fuel system designed for simplicity, reliability, and minimum requirement for fuel management. These design features obviate both the likelihood of flame-out due to poor fuel system management and the loss of power for operation of flight controls associated with single-engine failure. It was thus possible to provide safety and at

(*Continued on page 577*)

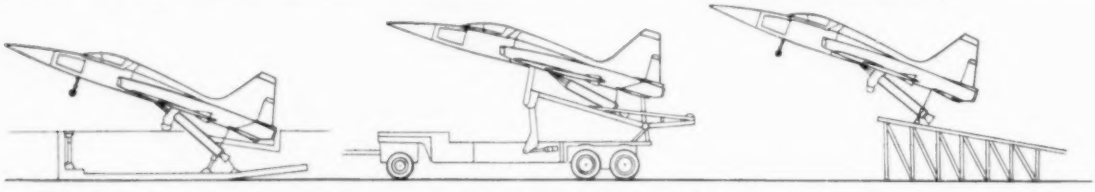
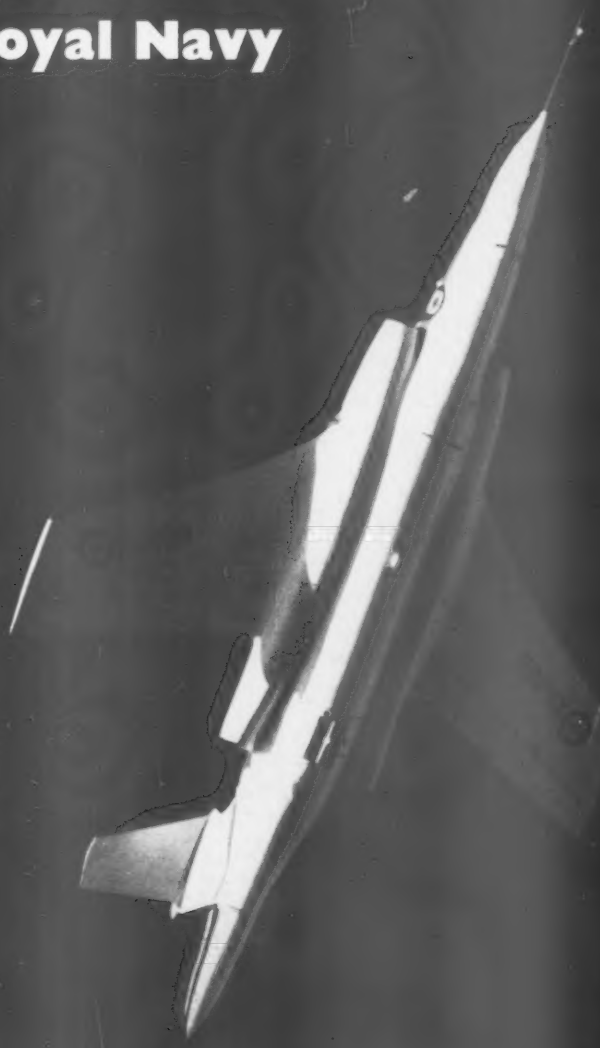


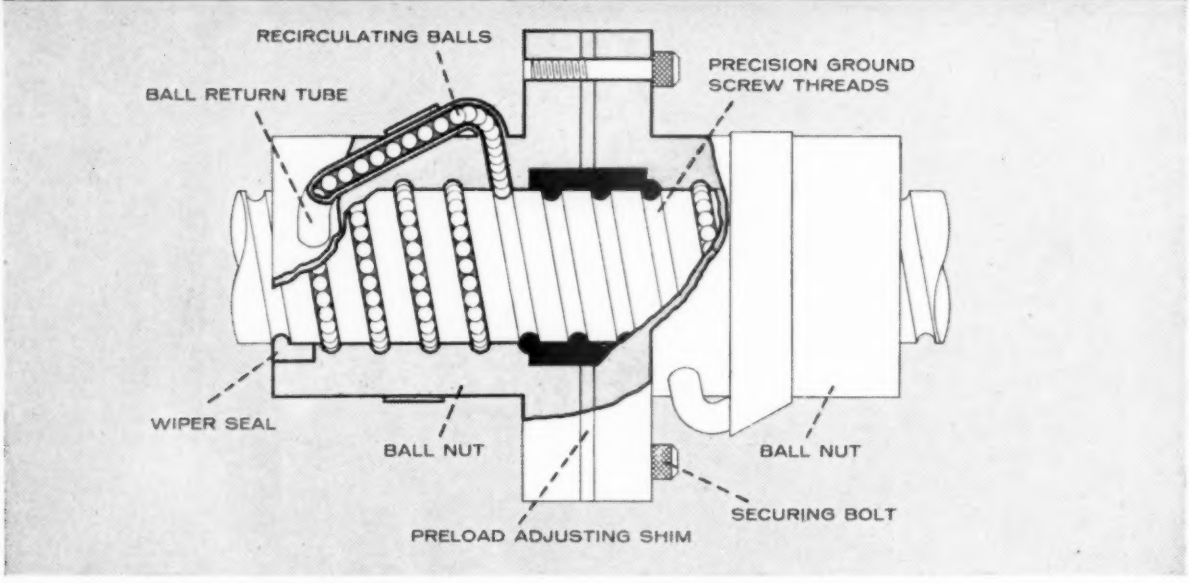
Fig. 2.—Zero-length Launching. The N-156F can be launched from either a fixed pit-type launcher or a portable ramp-type launcher from advanced bases with minimum site preparation.

The NA.39 has been ordered for the Royal Navy



BLACKBURN AIRCRAFT LIMITED BROUGH YORKSHIRE ENGLAND

Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



...ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

** Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.*

For further information please write to J. B. Starky, Sales Manager (Beaver Products Division), Bristol Siddeley Engines Limited, PO Box 17, Coventry, England.

BRISTOL SIDDELEY ENGINES LIMITED

Fig. 3. Jet Assisted Take-Off: For short, quick take-off without special launchers, or reduced take-off for carrying heavy payloads, four 1,000-lb.-thrust JATO units can be used.

(*Continued from page 576*)

the same time provide the simplest and most reliable electrical and hydraulic systems uncompromised by such devices as a ram air turbine.

Money Engineering

As a multi-purpose, all-weather, lightweight fighter and tactical fighter-bomber, the N-156F represents a fresh, rather than a new, approach to the problem of providing maximum air combat effectiveness for the needs of NATO, CENTO, SEATO and other allied nations at practical procurement and maintenance costs. It is the first application of U.S. funds and technology to the development of a fully fledged weapon system primarily for the use of foreign countries allied to the U.S.A. in Europe, the Middle East, Asia, Australasia and elsewhere. Northrop enunciate the following claims on behalf of their thesis that the N-156F will lessen the burden of U.S. military aid and provide allied governments with greater defence force effectiveness.

1. It is less costly to produce, operate and maintain than current fighters which would normally be furnished to allied nations under the Mutual Aid Programme, yet it delivers high combat performance. With current top-speed performance at 36,000 ft. in the Mach 1.5 class (with afterburning), the performance growth designed into the aircraft will provide an ultimate speed capability of Mach 2.2 with an advanced thrust-augmentation system of afterburner plus pre-compressor water-injection cooling, and a new variable inlet duct to match. This advanced propulsion system is now under joint development by General Electric and Northrop. The addition of water injection in the inlet duct upstream of the compressor almost *doubles* the engine-plus-afterburner thrust between Mach 1.5 and 2.2, a remarkable power jump which will be discussed further in Part 2, when we size up the performance characteristics. (Obviously, those Japanese photographers knew what to look for!)

2. It is designed to operate from the short advanced runways near the peripheral front-line areas, only a few seconds from the scene of possible air combat, with a minimum of ground support equipment. It will not be tied down to any complex base facilities and can be widely dispersed without increasing maintenance cost. The ability to use the standard U.S.A.F. zero-launching pads now available is part of the full weapon system. In connection with short landing capability, a novel footpad type of runway brake attached to the lower extremities of the main landing gear has also been proposed and illustrated. [An art st's sketch depicts a certain similarity to a recent Dowty patent.] Alternative proposals include the installation of four 1,000-lb-thrust JATO units fitted beneath the fuselage for achieving a short, quick take-off in about 1,200 ft., and the ground installation of a "liquid squeezer" arresting system which reduces the landing run to 1,060 ft. (See Figs. 2, 3 and 4.)

3. Simplicity of design makes it possible for allied governments to produce the fighter under licensing agreements, with a large saving in labour cost. For example, the Australian Government is clearly anxious to keep its aircraft industry on the learning curve, thus the N-156F is still under consideration by the R.A.A.F. as a follow-on to its North American Avon-engined F-86s. If the Rolls-Royce RB-145 small turbojet (with competitive augmentation devices) could be hooked into this deal, the N-156F appears to be the most manageable manufacturing proposition for Australia's Commonwealth Aircraft Corp. Bigger and much costlier American fighters are almost certainly a wistful dream that time and the taxpayer will roll away.

4. Simplicity of maintenance makes possible the use of lower manpower skill levels and will result in a larger ratio of combat-available aircraft at any given moment. For example, the U.S.A.F. quote a figure of 57.5 maintenance man-hours per flight hour for the Lockheed F-104A during the first half of this year. Most of the other century series fighters run between 40 and 50 man-hours for this maintainability index. Northrop's estimate of 21.5 man-hours for the N-156F is based on an actual U.S.A.F. finding of 14.3 man-hours for the T-38 and, bearing in mind the 80% interchangeability of components between the two aircraft, the company's estimate appears conservative.

The accompanying charts (Figs. 5 and 6) symbolize the lower costs of the N-156F weapon system in contrast to the higher costs of typical century series fighters now in use by the U.S.A.F. Fig. 5 depicts the yearly costs, beginning with research and development, and proceeding through procurement to maintenance and operation in service during the life of the weapon system. Included in the maintenance and operation costs is everything required to operate the weapon system effectively, such as fuel, installations, personnel, training, and replacement of aircraft damaged or destroyed in accidents.

There are two important points to note in this comparison. The first is that the total expenditure for maintenance and operation during the useful life of the weapon system exceeds the procurement expenditure for the weapon system and its spares. The initial procurement cost is frequently used in comparing one system with another; however, cost comparisons of this nature are misleading, since they do not cover the overall cost—particularly the large portion due to maintenance and operation—throughout the life of the weapon system right down to the operational phasing-out stage.

The second point is that the manner in which money is spent during the research and development phase has a tremendous leverage on the subsequent, and much higher, costs of procurement and operation. During the development phase, the physical

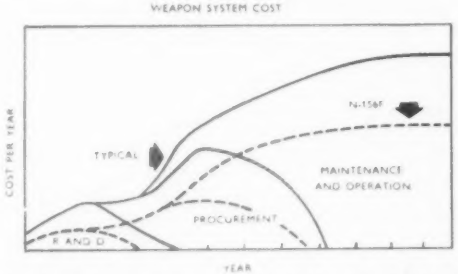


Fig. 5. Annual Cost Comparison, N-156F vs. Typical U.S.A.F. Fighter: Expenditures during research and development phases greatly influence total procurement and operation costs.

and operational characteristics of the system are determined according to the military requirements and the design philosophy established for the system. It is during this phase that future procurement and operation costs must be considered as a major parameter in the design. Attention to these factors during the design stage can result in significant reductions in weapon system

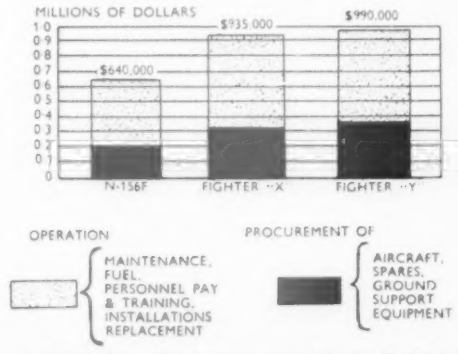


Fig. 6. Total Cost Comparison, N-156F vs. Typical U.S. Fighters: Total procurement and operating costs per aircraft per annum of N-156F vs. U.S. fighters "X" and "Y." Dollar values are for the complete weapon system.

cost, and a corresponding increase in total force effectiveness.

In Fig. 6 the total procurement and operating costs for the N-156F are compared with two typical supersonic fighters now in use by U.S. forces. These are estimated annual costs per aircraft, computed on the basis of a 75-aircraft wing. Included in the procurement are the initial aircraft procurement, amortized over a four-year period, spares and ground support equipment. Included in operation costs are all the factors required for operation—maintenance, fuel, payroll and training of personnel, installations and replacement of destroyed aircraft. These costs are based on U.S. standards. It will be noted that the costs of operation are significantly greater than the procurement costs, such that the latter represent only 30-35% of the total weapon system cost; also that total costs for he N-156F are approximately 60-65% of the costs of the other two fighters.

(To be continued)

Audacious Augmentation

I'm very fond of water:
It ever must delight
Each mother's son and daughter,
When qualified aright.
(LORD NEAVES.)

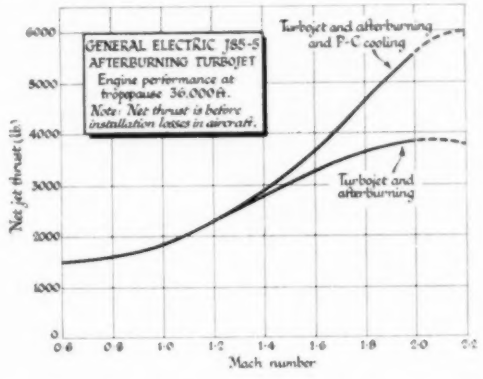
ONE may fairly assume that General Electric and Northrop were not only well aware of the poetaster's qualifications, but have technical qualifications of their own concerning the proper use of water injection when they made their recent joint announcement of a new form of turbojet wet boosting. For some time General Electric have been engaged in research and development of this advanced thrust-augmentation system using their J-79 turbojet as the wet nurse, so to speak. (We were surprised to stumble across a research bibliography containing 66 references on this subject over the period 1947-59!) More recently, General Electric have disclosed that their Small Aircraft Engine Department at Lynn, Mass., will shortly begin testing the application of this idea to the G.E. J85-5 afterburning jets soon to be installed in the Northrop N-156F.

Known officially as "pre-compressor water injection cooling," this joint G.E.-Northrop test programme, scheduled to begin in December of this year or early in January, 1960, is not to be confused with the current conventional system employing a large volume of water injected directly into the engine for the take-off. Whereas the conventional water injection system is utilized mainly to lessen the take-off hazard of underpowered (and underwinged) jet transports, and produces an initial thrust increment of the order of 15-20% at best, the pre-compressor coolant dodge, with the water spray nozzles installed well upstream in the air intake duct, is essentially a supersonic device that can boost the performance of a Mach 1.5 aircraft to well over Mach 2.0—as we propose to show later.

In its currently designed configuration for Mach 1.5-1.6 with the G.E. YJ85-5 afterburning engines, it will be seen from the cutaway drawing (p. 574) that the side air intake to each engine is of straightforward geometry and construction, being characterized by a vertical inner lip proud of the fuselage skin and an oblique or canted outer lip for efficient flow entry at climbing and manœuvring angles of attack. It follows, of course, that a more sophisticated form of variable inlet will be provided to match the Mach 2 (plus) capability, when this latest scheme of water spraying is pumped into the intake ducts. This modification, seen in the inset sketch, takes the form of a hinged vertical ramp for varying the inlet throat area and angle to match the Mach number. The variable geometry mechanism is automatically operated by a Mach sensing device, and so is the water injection. Also diagrammed in the separate sketch are the water spray bars and nozzles and attendant plumbing system, engine-driven water pump and water tank cell in the fuselage.

Apropos supersonic engine aspiration systems, the McDonnell F4H fighter for the U.S. Navy, powered with twin G.E. J79s, has a vertical ramp type of variable inlet closely resembling that now under development on the N-156F. The F4H is reported on the test apron at Edwards A.F.B., California, being groomed for flight testing with a pre-compressor water boost system, thus it is likely to be the first aircraft in the air with this new scheme of duplex fore-and-aft thrust augmentation. It is also reported (as might be expected) that Pratt & Whitney are running in the same race with a similar system applied to the J75 engine in the Vought F8U-3 Crusader and the Convair F-106 Delta Dart fighters, which clearly signifies that the aforementioned research documentation has not gone unnoticed by engine and airframe designers in the U.S.A.

The principles of pre-compressor cooling are related to the well-known fact that the thrust of a turbojet is sensitive to the inlet air temperature at the compressor; thus, at sea-level under hot day conditions, the thrust deteriorates with increasing temperature. This sensitivity to variation in air temperature also applies to an increase in Mach number; e.g., at Mach 2.0 in the stratosphere (36,000-82,000 ft., ambient air temperature −69.7°F.), the engine inlet air temperature is approximately 250°F. due to ram pressure in front of the compressor. Aerodynamically, the effect on the compressor is that of operating at progressively lower r.p.m., with decreasing air mass flow through the engine. Pre-compressor water injection cools the air in the inlet duct, compensating



for the increasing inlet air temperature associated with higher Mach numbers. By virtue of the evaporative cooling of the air, the water extracting heat from the air before aspiration at the compressor, the mass flow through the engine is restored and hence the thrust. At a speed of between Mach 1.3 and 1.4 the ram air temperature rise is sufficient to ensure proper evaporation of the water particles.

General Electric say that this new application of water injection to the turbojet differs radically from that currently employed on the big U.S. commercial jet transports in that it utilizes the evaporative cooling effect of water as opposed to increasing the mass flow by dumping a large volume of water through the engine. They quote comparative water consumption figures for the latter (conventional) method of the order of 10 times the quantity required for pre-compressor evaporative cooling. As a matter of record, we were surprised to find that the Boeing 707 and Douglas DC-8 have provision for some 6,000-7,000 lb. of water—which is a lot of non-pay dirt to hoist off the already overstretched runways. Northrop's figures also confirm this 10/1 ratio; they quote a consumption of 5 lb. of water per lb. of fuel burnt for the older method against 0.5 lb. water per lb. of fuel for the N-156F.

An earlier Mach 2.0 scheme of Northrop favoured the addition of extra water tanks (or bags) in the wing-root, since the wing happens to be dry with all the fuel tankage in the fuselage. In the latest schematic, illustrated on p. 574, they have settled for a simpler alternative arrangement albeit with a slight penalty in range in the basic clean fighter configuration without external fuel tanks. When modified for Mach 2.0 (plus) capability, a fuselage dorsal fuel tank of 54 U.S. gals. capacity will be utilized for the water coolant system. The substitution of water for JP-4 fuel adds approximately 100 lb., while the complete water injection system and variable inlet modifications are estimated to add a further 300 lb.; thus the current gross weight of the basic N-156F fighter will be increased from 12,200 to 12,600 lb., which looks like a petty price to pay for changing a sesquisonic performer into a bisonic one.

Seeing that the engine performance curves of the J85-5 are still wrapped in an official mantle of security-cum-obscurity, we have had recourse to certain well-tried empirical rules when "plotting" the thrust curves (at the top of this column) for the standard tropopause height of 36,000 ft. Starting with the known official sea-level rating of 2,500 lb.s.t. (dry) and 3,850 lb.s.t. (afterburning), and an assumed power drop factor of 40% at 36,000 ft. at M=O, the "turbojet+afterburning" curve has been established at M=O, 1.2 and 2.0 with fair accuracy. At Mach 2.0 the additional augmentation yielded by the water coolant is of the order of 40-50% and so we have settled for an addition of 45% to establish the "turbojet +afterburning+p-c. water cooling" curve. The significance of the latter in relation to the N-156F aircraft is that it lies comfortably above, and practically parallel with, the drag curve all the way from Mach 1.2 to beyond Mach 2.0. This is the kind of thing that makes the aircraft designer's mouth water!—S.H.E.

THE BLACK KNIGHT IS SURE OF SHELL

photo by courtesy of Saunders-Roe Ltd.

The Saunders-Roe Black Knight is a rocket with lofty ambitions. So naturally Saunders-Roe wanted to be sure of its fuel.
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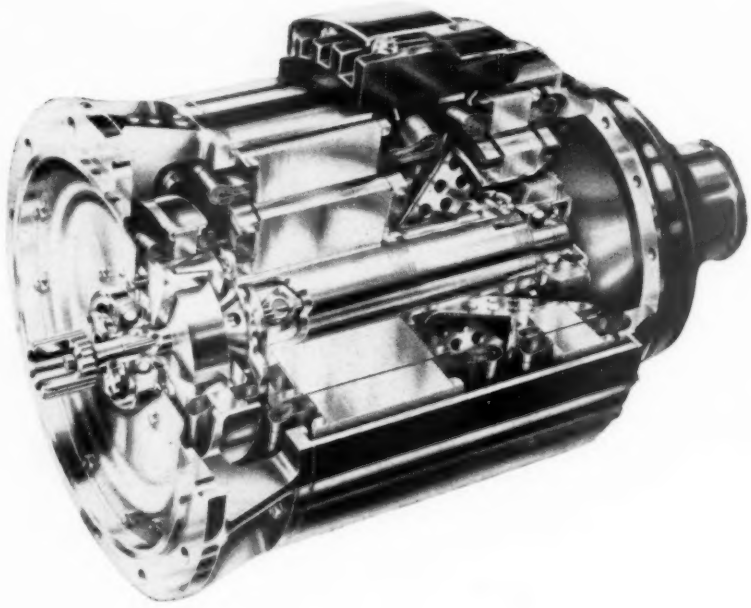
Abolishing the brush-gear on this English Electric AC Generator has brought about an altogether new order of reliability, life between overhauls and low maintenance costs. In conjunction with the Sundstrand constant-speed drive unit it has solved all the problems of efficient, economical and safe electrical systems for modern, high-altitude aircraft, civil or military.

The Alternator shown is the Type A.E.2043, giving 40 kVA for a weight of 86 lbs. It has a low synchronous impedance which, together with the integral excitation system, ensures that a high short-circuit current is available for fault clearing.



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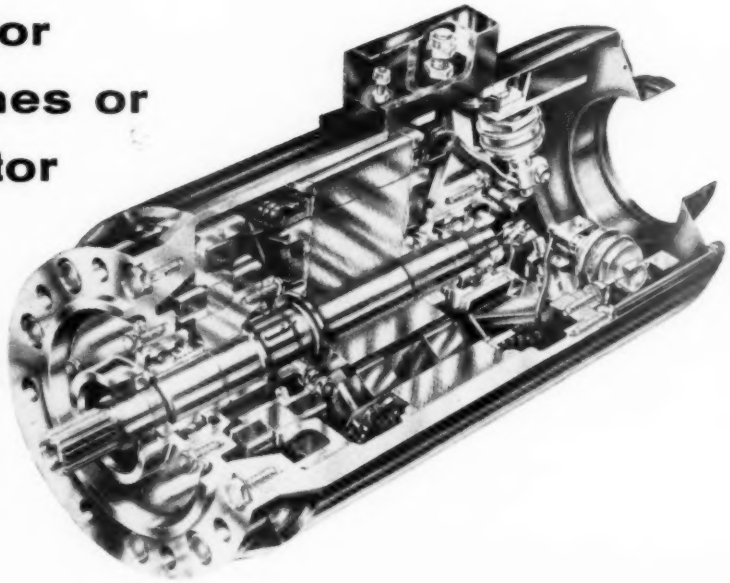

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Personal Flying

Returning to the vexed question of the English winter, and its calamitous effect on personal flying, which was discussed in the front pages of our previous issue, several things can be done to avoid the reckless forced-landings of virtually weekly frequency. Seldom is anyone hurt in these incidents, although club and privately owned light aircraft are often bent. In bad light, however, it is only too easy to hit an obstruction on the approach, which can be very fatal, and there is always the danger to people on the ground.

Between mid-October and mid-March, it is therefore best to assume, for safety's sake, that whatever the weather in terms of daylight, visibility towards dusk will deteriorate to well below VMC minima. In fact the better the weather, the more likely this is to happen. The odd thing is, however, that, with complete darkness, visibility frequently improves to a figure far superior to anything observed during the day.

This is particularly true in the vicinity of large towns, where it is probably advisable to terminate all except local flying about an hour before sunset. On a statistical basis, it is quite probable that on the average, conditions are more suitable at night for "contact" flying than during the day, in the winter.

Unfortunately, most club and private aircraft are even less well equipped for night flying than for daylight operations. While their owners can do a certain amount to rectify this situation, all the radio and navigational facilities in the World are of little use without corresponding ground equipment.

How many club airfields in the U.K. are equipped with VHF, let alone VDF? And how many have night-flying lighting, apart from half a dozen flickering goose-neck flares and a 1914-18 glide-path indicator? What provision is there for a private pilot to call for a fix, to avoid getting himself (and everybody else) in a jam through becoming lost on his primitive map-reading? When are we going to get a moderately priced VHF set and a radio compass for light aircraft installation, and a common frequency for personal flying use? When are we even going to get representation to get these things?

Until some of these questions are answered, and we have a higher overall standard of airmanship, private pilots will continue to plough the fields and scatter, not to mention blundering into international airport circuits, to the detriment of themselves and their week-end flying. But the last word on bad-weather flying, we feel, should go to Biggin Hill's "Methuselah" Marshall. "I much prefer," he is quoted as saying, "to be on the ground wishing I was in the air, than up in the air wishing like hell I was on the ground."

• • •

As we forecast last week, the indefatigable Max Conrad has established another light aircraft long-distance record with a flight from Casablanca, Morocco, to El Paso, Texas, a distance of 6,911 miles. This was accomplished in the same Comanche used for his June flight of 7,683 miles, re-engined with a 180 b.h.p. Lycoming for the lower weight category. He beat by 1,954 miles the 10-year Bonanza record of the late Bill Odom.

• • •

● After 20 years' inactivity, the Norfolk and Norwich Aero Club has been brought back to vigorous life. An Air Centre has been opened in Norwich for social and ground instructional purposes. Flying activities are undertaken at Swanton Morley airfield. There, a large caravan loaned by Messrs. Filtrate Oils, Ltd., is being used as a temporary clubhouse, and two Tiger Moths are now operational.

● Associate member of the A.B.A.C. is the new Alouette Flying Club, which operates from Biggin Hill with a Taylorcraft. This has a long-range tank and several other mods. and flies for 52s. per hour. A fully qualified instructor is available for *ab initio* training, and a course of ground instruction is being prepared.

● Other Biggin news comes from Rollason Aircraft and Engines, Ltd. As the result of taking additional accommodation there, Rollasons now welcome Cs. of A., repair and maintenance work on all types of light aircraft. The company can also offer hangarage on short or long terms.

Gliding Notes

by Dr. A. E. Slater

NOT having received the latest Newsletter from Slingsby Sailplanes, either personally or through *Sailplane and Gliding*, I concluded in the issue of November 6 that it was no longer sent to the Press. However, Fred Slingsby writes that this is not so, and that the mailing list includes four British aviation magazines, one of them being *Sailplane and Gliding*, though that copy did not reach me.

Slingsby's appears to be the only glider manufacturing firm in the World to send out regular newsletters, though the Scheibe firm in Germany used to do so when Martin Deskau was working for them; they could not cure him of the habit of giving publicity to sailplanes, which he had acquired as assistant editor of *Thermik* through many years. Detailed newsletters come at irregular intervals from Charles Fauvel about his flying wings, Elliotts write occasionally, and Schweizer sometimes sends photographs.

• • •

AN unusually long cloud street is reported in *Souring* for September by Charles Yeates. On July 11, the day after the Canadian National Contests ended, he put up a new national distance and goal-flight record of 325 miles from Regina in a Schweizer 1-23. With the help of a 10-15 m.p.h. tail-wind he took 6 hr. 20 min., but the most exciting part was a flight under a cloud street 51 miles long at 73 m.p.h. average, with no loss of height and without throwing a circle. He could obviously have traversed the same street in an upwind direction at only 25 m.p.h. less ground-speed.

Those who invent theories about cloud streets can always say why they form, but can never explain why they should be of any particular length, except that short lines of separate cumulus clouds, all coming from the same source, are obviously limited by the lifetime of the individual clouds. The reason for extra-long cloud streets seems to be mainly topographical, and Yeates' route took him south-eastwards along high ground on the N.E. side of a long valley, according to the map. Our Met. Office's weather chart for that day shows Regina in a large anticyclonic area with westerly winds of force 2, so the cause was not strong winds.

• • •

AT Lasham on Nov. 11, unusually active thermals for the time of the year were found by Sir Roger Conant (spokesman for Gliding in the last Parliament) in the Army Club's Skylark 2. Around midday he found a weak thermal at about 650 ft. which improved higher up to a steady 10 ft./sec. all round the circle and occasionally reached 20 ft./sec. Having no permission to go into cloud, nor to set off cross country, he had to stop climbing at 2,600 ft., though the cloud above him continued to grow, apparently for as long as an hour, and he only left its base even then because others wanted to fly the machine. A T-21 two-seater had soared with him, but after that nobody could find lift.

The air which provided this late-season lift had left the east coast of Greenland three days before, and must have reached Ireland two days later in a very unstable condition, with its surface layer warmed up by the Atlantic to about 44° F. Ireland hardly became warmer than this on Nov. 10, but South-East England on the 11th reached maximum temperatures of 47° and 49° F.; hence the thermals, though Sir Roger thinks they were only active for two hours at the most.

Before this, the latest reported thermal flight of the year was a "C" flight by R. W. Younger at Cambridge at the end of October. As to summer thermals, the club's newsletter states that on one day last summer more flying hours were logged by the club fleet than during the whole period from the previous October to February inclusive.

• • •

PUTTING up a height record for Rhodesia, Richard Prestwich, formerly of the Midland Club, reached 26,000 ft. in a cumulo-nimbus after a launch to 5,500 ft. in a Skylark 2 at the Salisbury Gliding Club on Nov. 1. It is about two years since he went to Africa, after trying in England to organize an attempt on the Helm Wind wave, which refused to blow.

The Salisbury Club concluded a most successful "winter" (it is in latitude 18° S.) with a record for flying hours in August, giving an average time per flight of 91 minutes for its single-seaters.

Farther south at the Cape, the first cross-country of spring was made on Oct. 18 by Helmut Morsbach, of the Peninsula Club, who took an S-18 two-seater 25 miles and reached 4,400 ft.

Correspondence

Electronics in Aircraft

READING the brief report in your issue of November 6 of a talk I gave to the Radar and Electronics Association about electronics in supersonic flight, I feel that in fairness it should be mentioned that 95%, or more, of this described the very important part that electronics play in the design, testing and operation of supersonic aircraft. It was not, as may have been deduced from your report, a lecture consisting wholly of criticism! The lecture made it clear that the many design processes and much of the systems and operational equipment, and indeed the safety of the aircraft, were dependent on electronics. It ended with a forecast that long-range supersonic aircraft, either military or civil, were likely to contain an even greater amount of airborne electronic aids, as compared with the supersonic fighter. It was also suggested that the technical basis for these airborne aids was reasonably well established and that, therefore, in view of the extent to which the aircraft engineer has to rely on these aids, attention might well be directed in the future to improving:—

(a) Greater reliability by various means; and (b) a reduction in bulk by development in micro-circuitry.

Preston, Lancs. F. W. PAGE.
(Chief Executive, Aircraft Division, English Electric Aviation, Ltd.)

[The points about the increasing importance of electronics made in Mr. Page's letter are not in dispute, but the most newsworthy part of his lecture in our view was the section headed "Conclusions" which we quoted in full. Our note certainly did not imply that this section formed the main part of his lecture. But it is usual to assume that the "conclusions" section of a lecture covers the points which the lecturer considers to be the most important.—ED.]

"The Jet's Organic Hum"

RECENTLY B.O.A.C. have confirmed that they are to play sweet music in their Boeing 707s before take-off and after landing. Matters have progressed much further in the United States, as the following relevant cutting from *The Reporter* shows:

FASTEN YOUR EAR-PLUGS

"Northwest to Waft Passengers on Wings of 'Heavenly' Music. . . . The airline has hired six professional organists . . . to rotate on flights."—The New York *Times*.

"Electric organs on the ground
Produce abominable sound.

"Electric organs in the air
Are certain to induce despair

"In belted prisoners of seats
Who cannot flee the awful bleats.

"Let all who travel to this tune
Cry out their protestation soon.

"So that committers of the crime
Dismiss the organists in time;

"And let the sole harmonium
Remain the jet's organic hum."

New York. CHRISTOPHER CLARKSON.

The Elegant Little Tiger Moth

MAY I be permitted to come to the defence of the Tiger Moth, so slightingly referred to in your Personal Flying column on October 23? Like any machine the Tiger Moth has its limitations: but to those of us private flyers whose pleasure in flying lies mainly in trying to acquire a skill, I should have thought that the limitations of the Tiger Moth were unimportant, especially when compared with the many virtues of this elegant little aeroplane.

The private flyer of modest means can seldom fly sufficiently often to develop his potential skill to the limit, and he is often to some extent out of practice; he needs a machine which is sensitive so that sloppy flying is at once discouraged, and yet one which can be mishandled quite severely without it doing anything desperate, this particularly in the early stages of learning to fly.

The Tiger Moth satisfies these requirements completely; to refer to it as a "contraption" implies either ignorance of the definition of this term, or else little appreciation of the first-rate design and construction of this aircraft which gives such rewarding pleasure to those to whom even being in the air can be an end to itself.

Newbury, Berks. BILL HARDY.

Man-powered Controls

IN none of the writings about the prospects of man-powered flight have I seen any reference to the real problem—that of control. Half a century ago the pioneers learnt the lesson that getting an aircraft off the ground was only a small part of the difficulty of flying.

No one who is putting out the physical effort necessary to get into the air, and to stay there, however briefly, is likely to be a very effective pilot and the difficulties will be increased by the obvious necessity, in the case of man-powered aircraft, to use unconventional control methods.

These new methods ("levers" and "grips" have been vaguely mentioned) will need to be practised through dozens of airborne hours before they become instinctive—and unless they *are* instinctive the first successful man-powered aeroplane is likely to complete its flight as a heap of wreckage.

London, S.W.3. H. A. TAYLOR.

[Another letter on this aspect appeared on November 20.—ED.]

The Lure of the Non-practical

IT is a sobering thought that the greatest publicity in the general Press that the Royal Aeronautical Society has achieved was inspired by its most airy-fairy non-practical section so far.

One is taken back to the days when the A.S.G.B. was talking of powered flight when man had barely ballooned.

It seems a pity that the R.Ae.S. did not cash in earlier—and has not cashed in yet—on interplanetary flight and, since the Moon has successfully been cried for, one can only suggest the Society sets its sights a little higher.

London, W.1. "WAYLAND."

Not the York!

IN his admirable article on the Caribou, John Fricker refers to the overhead engine control console and says he "had not previously encountered this type of layout."

Surely, he has at some time flown in that old warhorse, the York!

I trust he will forgive my gentle criticism.

Carlisle. RAYMOND HANCOCK.

[Surely he hasn't.—ED.]

"Strength Through Fear"

I READ with fascinating horror the viewpoint of Mr. Norman Jones in his article on "Fear of Collision in the Air" on November 20.

My first reaction to this most remarkable confession of a private pilot is that Mr. Jones must be an extremely lucky man, as adherence to such a code of airmanship must have involved him in many hair-raising experiences.

His outcry about the existing regulations is, to say the least, quite extraordinary, especially as it is blatantly obvious that he does not know them. The charming little anecdote about the Chipmunk and the railway line is a perfect example. Surely after 30 years of flying, Mr. Jones should realize that a pilot should keep to the right-hand side of any line feature that is being followed, and by practising this elementary safety rule there would have been no necessity for his having to turn "a little to the right."

You mention in your Editorial the occasion of the near miss caused by the Service aircraft, but the more recent closure of L.A.P., due to the antics of a private pilot with perhaps similar views to Mr. Jones', deserves the most strict disciplinary action to ensure that all such infringements by future offenders will be severely dealt with.

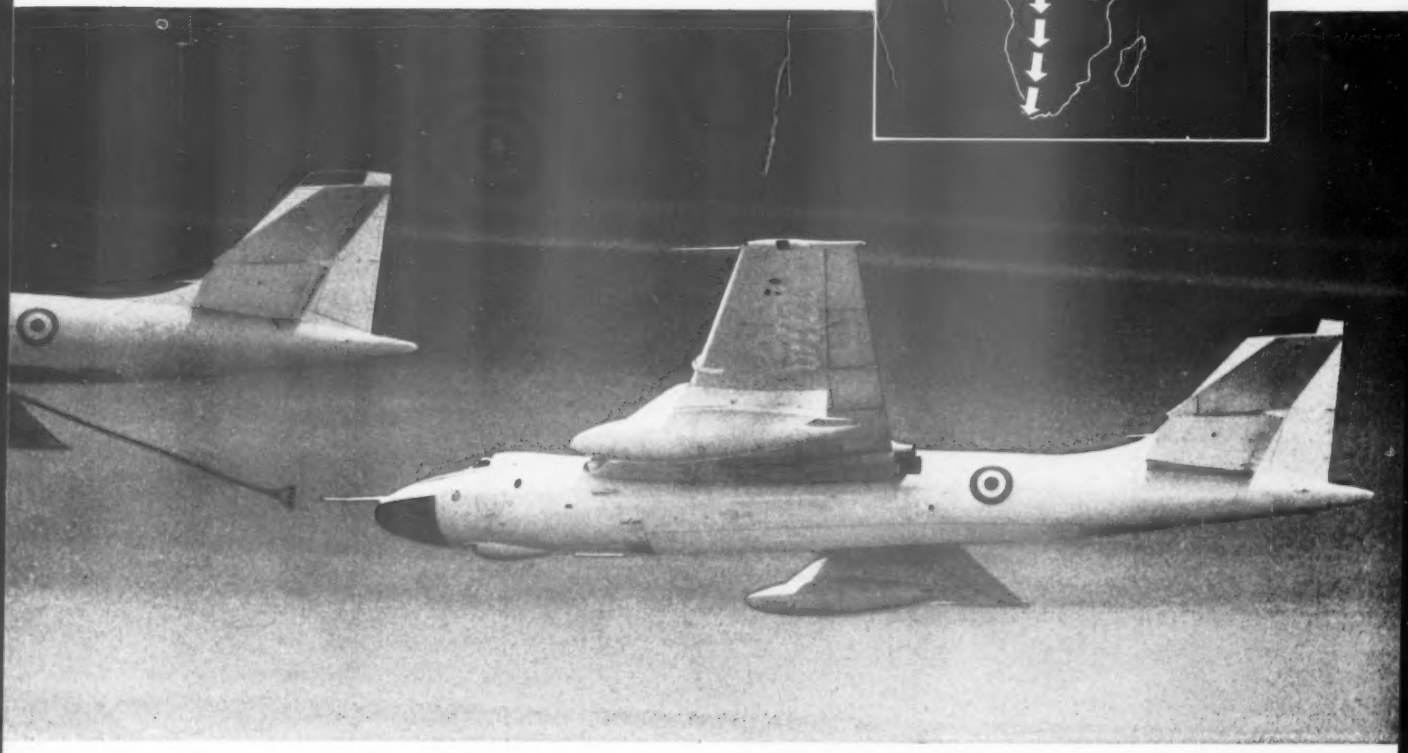
I thoroughly enjoyed the section of the article on how to fly by instruments, especially the added precaution of keeping a sharp look-out in cloud, as practised by all good ships' masters, and it would give me the greatest pleasure to be able to see the face of the author of this little gem when the captain of an airline aeroplane, on a full IMC let-down, advised the fare-paying passengers that there was an unidentified aeroplane in the near vicinity.

Might I suggest a new pattern of flying, say 1984 style?

"I say, chaps, what about a session of making faces at each other in the London Control Zone? I'm sure I've got a new wrinkle on our 'strength through fear' routine. Right, let's go. Weather? Perfect, full India Mike Charlie, and we might even get a crack at one of the big boys on his let-down, and you know how Big B. loves to give out the gongs for closer

(*Continued on page 581*)

TANKING UP IN MID-AIR. *Valiant-to-Valiant hook-up! Mid-air refuelling techniques by giant aircraft such as these vastly increase the range of our V-bombers. Already flights of 6,000 miles have been made, including a non-stop flight from London to Cape Town.*



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Few professions demand higher qualities than a flying career in the R.A.F.—a challenge to any young man who has ever felt the urge to fly. You may think there's no future flying manned aircraft in the R.A.F.—but you would be quite wrong. Manned aircraft will be needed in vital roles such as the V-bomber force, certain air defence duties, tactical support, all types of reconnaissance and air transport for many years to come.

And as guided missiles play an increasing role in our defence, it is the men with flying experience who will command the units that use them.

One last point. Today many careers offer good pay and conditions. The R.A.F. is one of them. Materially, an officer in the R.A.F. looks his civilian contemporaries squarely in the eye . . . and gets a lot more out of life.

For details of how to apply, of pay, conditions and allowances write to: The Under Secretary of State, Air Ministry (M.9) (AP30a), Adastral House, London, W.C.1. (Applicants must be between 17½ and 26 and have gained a good G.C.E. or equivalent.)

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A Flight Lieutenant of 26 can earn, with full allowances, nearly £1,700 a year. The R.A.F. wants pilots, navigators and air electronics officers for three types of commissions: (1) Permanent, leading to retired pay. (2) 12 years, with the option of leaving after 8 years and the chance of gaining a permanent commission. (3) 5 years, also with the chance of gaining a permanent commission.

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WPS 357

(*Continued from page 580*)

than that near misses. I've filed 20 this week.

"Look fellars, I'm at a hundred feet below solid cloud, but it's lucky I've got my Mark XX new-style reliable altimeter with me. I'm glad they got rid of that QNH business, it never was any good, and so confusing too.

"Here we go, into cloud, and remember the new rules. Fly slowly, just above the stall, and the obvious way to do that is wheels down and full flap. That's better, now if anything is coming the other way I can make a quick emergency landing and the noise of my engine will not annoy the locals. Must also keep a sharp look-out.

"Think I'll call up on the radio for a bit of fun. You never know, I might hear of a big one in the near vicinity.

"'London, this is Golf (What was the phonetic for "A"?). Oh, well, it's me, London. Full IMC without a rating at a hundred feet, position unknown, but believed to be in the middle of the Control Zone. Is there a bearing I can ignore? Over.'

"No reply. I wonder if it was due to that other idiot that was talking at the same time as me. Some people are so rude on the RT nowadays.

"A break in the cloud. Where am I? Cor! right over the duty runway at L.A.P. This is worth at least 60 points. Whacko, a Comet 22, I wonder if I can get close enough to make a face at him? Blast, he's not obeying the bad visibility rules; he's flying above the stall.

"Hello, chaps, did you have a good trip? I've had a heyday. Fact is I feel so good I think I'll go and have a crack at logging some near misses on the M44."

Ad nauseam. . . .

It is my sincere hope that I never have the misfortune to be in the air in IMC with several unsuspecting fare-paying passengers when Mr. Jones is practising his more unusual ideas about flying.

ADRIAN M. ROSS,
Director, Trans-European Aviation, Ltd.

Swansea.

Fear of Collision—an Airline Pilot's Reply

"FEAR, as the philosophers say, is ever a bad counsellor, and there is no doubt that it has been responsible for much of the bad counsel which has got into the Air Traffic Control regulations in Great Britain. . . ." So wrote Mr. Norman Jones, a private pilot of 30 years' standing, in an article on November 20 representing a private pilot's point of view on the collision hazard.

The quotation sounds good, but it has no relevance to this difficult problem. Regulations for air safety are made with the obvious apprehension of the appalling dangers that would exist without them, and it is principally because of such organized and controlled flight path that the risk of mid-air collision is minimized.

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Consider the London Terminal Area. A constant stream of airliners is using the United Kingdom Airways System in both directions. Frequent position reports with flight level and ETA for the next reporting point are passed to ATCC by the aircraft. These data are carefully checked and compared for conflicting traffic. In addition, the ever-watchful eyes of Radar are scanning the sky for the unexpected, and to give assistance whenever it is needed or asked for.

The separation of descending and ascending aircraft is taken care of. Inbound aircraft arrive at the Epsom and Watford range stations, and hold there in a racetrack pattern, awaiting their turn to descend through the London Control Zone into their destination airport. As the aircraft are taken off both stacks by the Approach Controller, so the two streams are sequenced together, so as to form a regular approach pattern. It is this organization which enables airliners of different speeds and characteristics to land at the rate of one every 60 sec.

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But, install the minimum equipment and become knowledgeable of the rules and procedures, and a private aircraft has the same rights and will receive the same assistance and co-operation from ATCC and ATC as a large transport aircraft. A few years ago, during a busy summer afternoon, I was landing at London Airport in a Proctor. (Permission had been gladly given previously by the Airport Commandant.) A Boeing Stratocruiser was told to land after the Proctor four miles ahead of him, and to advise if he did not have it in sight. The Stratocruiser captain was horrified. "Did you say a *Proctor*?" he asked, as if he had suddenly been assailed by a nasty smell. "Would you hold him off, please, or give me another runway?" "Negative," replied the controller, "the Proctor is No. 3 and you are No. 4 to land. Land after him on 28 Left."

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SANGAMO WESTON INSTRUMENTS

—chosen for reliability and accuracy

Sangamo Weston electrical measuring instruments were supplied for the ground installations and testing of the Saunders-Roe Black Knight Missiles.
Sangamo Weston are proud to have played a part in achieving the outstanding success of this project.

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WPS 257

(*Continued from page 580*)

than that near misses. I've filed 20 this week.

"Look fellars, I'm at a hundred feet below solid cloud, but it's lucky I've got my Mark XX new-style reliable altimeter with me. I'm glad they got rid of that QNH business, it never was any good, and so confusing too.

"Here we go, into cloud, and remember the new rules. Fly slowly, just above the stall, and the obvious way to do that is wheels down and full flap. That's better, now if anything is coming the other way I can make a quick emergency landing and the noise of my engine will not annoy the locals. Must also keep a sharp look-out.

"Think I'll call up on the radio for a bit of fun. You never know, I might hear of a big one in the near vicinity.

"'London, this is Golf (What was the phonetic for "A"?). Oh, well, it's me, London. Full IMC without a rating at a hundred feet, position unknown, but believed to be in the middle of the Control Zone. Is there a bearing I can ignore? Over.'

"No reply, I wonder if it was due to that other idiot that was talking at the same time as me. Some people are so rude on the RT nowadays.

"A break in the cloud. Where am I? Cor! right over the duty runway at L.A.P. This is worth at least 60 points. Whacko, a Comet 22, I wonder if I can get close enough to make a face at him? Blast, he's not obeying the bad visibility rules; he's flying above the stall.

"Hello, chaps, did you have a good trip? I've had a heyday. Fact is I feel so good I think I'll go and have a crack at logging some near misses on the M44."

Ad nauseam. . . .

It is my sincere hope that I never have the misfortune to be in the air in IMC with several unsuspecting fare-paying passengers when Mr. Jones is practising his more unusual ideas about flying.

ADRIAN M. ROSS,
Director, Trans-European Aviation, Ltd.

Swansea.

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NOTES AND EVENTS

BP IN THE AIR.—A 10,000-gal. Saro-built Air BP super fueller being loaded on board ship for transport to Canada, where BP is to supply fuel to T.C.A.'s fleet of DC-8 aircraft due to come into service in 1960.

ACCUMULATORS. — Copies of a recently produced catalogue covering the range of lightweight silver-zinc accumulators made by Venner Accumulators, Ltd., are available from the company at Kingston By-pass, New Malden, Surrey.

"THE AEROPLANE" INDEX

NOW available is the index to THE AEROPLANE, Volume 96 (January-June, 1959). Copies can be obtained on receipt of 4d. to cover packing and postage. Applications should be made to Temple Press Limited, Bowling Green Lane, London, E.C.1.

FIRE SUPPRESSION.—After several years' work in collaboration with M.o.S., British Oxygen Aviation Services have developed an explosion suppression system for use in aircraft fuel tanks. The makers say that the system provides continuous protection from fire and explosion risks, and also that it can readily be integrated with existing installations. Protection can be provided for a weight of 12 lb. for every 1,000 gal. of fuel carried.

NEW STANDARDS. — British Standards recently introduced include those covering "Electrically bonded aircraft fuelling hose and hose assemblies" (B.S.3158:1959); and "Cotton tape for aeronautical purposes" (B.S.2F49). Copies of these standards, price 4s. and 2s. 6d. respectively, may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

BRITISH CIVIL AIRCRAFT.—In our note regarding this new book—on page 454 of our issue for November 6—we gave its number of pages as 157; this should have been 576 pp. "British Civil Aircraft," by Mr. A. J. Jackson is published by Putnam and Co., Ltd., at 63s.

REFUELLING. — A filter-funnel is being marketed by Simmonds Aerocessories, Ltd., for use on airfields for over-wing hand refuelling. It has an earthing connection, weighs 16 lb. and can handle flows of up to 25 l.g.p.m.

Company Notices

New Companies

Senator Transport, Ltd. (640,683).—Private co. Reg. October 28. Cap. £2,000 in £1 shs. Objects: To carry on the business of haulage contractors, by land, sea or air, etc. Directors: Michael P. Lucey, Great Elm, nr. Frome; Barrington P. Harvey, King's Head Inn, Coleford, Bath. Sec.: G. Norman. Reg. office: 1 South Parade, Bath.

Soaring Holidays (Glider Hire), Ltd. (641,024).—Private co. Reg. Nov. 2. Cap. £100 in £1 shs. Directors: Thomas I. Q. Hall, 36 Meadow Road, Farnborough, Hants; Mrs. Ada M. Wood, "Morland," Glen Eyre Road, Bassett, Southampton. Sec.: Ada M. Wood. Reg. office: 121 Commercial Road, Southampton.

Rhoose Aviation, Ltd. (640,848).—Private co. Reg. October 30. Cap. £100 in £1 shs. Objects: To carry on the business of operators and charterers of aeroplanes and other aircraft, etc. Directors: David R. Lewis, "Kavavid," Holybush Road, Church Village, Glam.; James P. F. Cavanagh, "Manworthy," Fonmon Road, Fontigary, Rhoose, Glam.; Howard D. Williams; Arthur H. Hesp; Robert Brailey; John R. M. Coombe. Sec.: R. Brailey. Solrs.: T. J. Morgan and Co., Penarth. Reg. office: 26 High Street, Cardiff.

CHANGES OF NAME

Improved Propeller Shafts, Ltd. (587,657), 6 Bishopsgate, E.C.2.—Name changed to Harrison Lundgren, Ltd., on July 7, 1959.

C. E. Harper Aircraft Co., Ltd. (230,634). 62 New Broad St., E.C.2. Name changed to Harper Engineering and Electronics, Ltd., on July 6, 1959.

Air Trainers Link, Ltd.—Name changed to General Precision Systems, Ltd.

Aviation Calendar

December 7.—R.Ae.S. Boscombe Down Branch lecture, "Blind Landing," by W. J. Charnley, at the Lecture Hall, A. and A.E.E., **Amesbury**, Wilts, at 17.30 hrs.

December 7.—R.Ae.S. Derby Branch lecture, "Mechanical Design Aspects of the R.A.29," by F. Morley, at the Rolls-Royce Welfare Hall, Nightingale Road, **Derby**, at 18.15 hrs.

December 8.—R.Ae.S. Luton Branch Young People's lecture, by A. W. Bedford, at the Lecture Hall, Luton College of Technology, **Luton**.

December 8.—R.Ae.S. lecture, "Some Practical Aspects of Compressor Blade Vibration," by Dr. E. K. Armstrong and R. E. Stevenson, at 4 Hamilton Place, **London**, W.1, at 19.00 hrs.

December 9.—R.Ae.S. Weybridge Branch lecture R. K. Pierson Memorial Lecture, by H. H. Gardner, at the Apprentice Training School, Vickers - Armstrongs, Ltd., **Weybridge**, at 18.10 hrs.

December 9.—R.Ae.S. Brough Branch lecture, "Deck Landing of Naval Jet Aircraft," by D. Whitehead, at the Royal Station Hotel, **Hull**, at 19.30 hrs.

December 9.—R.Ae.S. Chester Branch lecture, "Experiences of an Air Line Pilot," by Capt. O. P. Jones, at the Lecture Theatre, Grosvenor Museum, **Chester**, at 19.30 hrs.

December 9.—R.Ae.S. Christchurch Branch lecture, "Hovercraft," by D. Stanton-Jones, at the King's Arms Hotel, **Christchurch**, at 18.15 hrs.

December 9.—R.Ae.S. Hatfield Branch lecture, "Wind Tunnels," by J. A. Kirk, in the de Havilland Restaurant, **Hatfield**, at 18.15 hrs.

December 9.—R.Ae.S. Southampton Branch lecture, "Experiences of the Trans-Antarctic Expedition," by Wg. Cdr. J. H. Lewis, in the Engineering Lecture Theatre, **University of Southampton**, at 20.00 hrs.

December 10.—R.Ae.S. Cheltenham Branch lecture, "The Development of Automatic Landing for Civil Airline Operations," by K. Fearnside, at St. Mary's College, **Cheltenham**, at 19.30 hrs.

December 11.—R.Ae.S. Symposium on Flight Safety, at the Institution of Mechanical Engineers, Birdcage Walk, **London**, W.1, at 09.45 hrs.

Personal Notices

BIRTHS

Chambers.—On November 17, at 65 O.M.Q. R.A.F., Peterborough, to Honor (*née* Crowley), wife of Flt. Lt. T. E. B. Chambers—a daughter.

Davie.—On November 18, at R.A.F. Hospital, Ely, to Jane (*née* Francis), wife of Flt. Lt. D. Davie—a son (William David).

Gatehouse.—On November 13, at Tidworth Military Hospital, to Ena, wife of Sq. Ldr. W. J. Gatehouse—a son (Christopher).

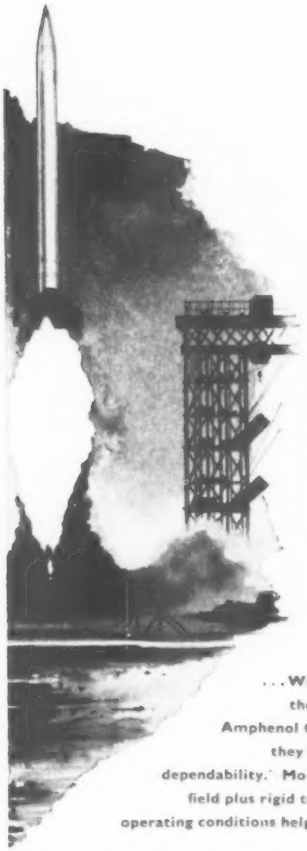
John.—On November 11, to Diane (*née* Hotchkiss), wife of Flt. Lt. L. John—a son (Robert Wesley).

McGlashan.—On November 13, to Doreen, wife of Sqn. Ldr. K. B. McGlashan, A.F.C., R.A.F. (retd.)—a daughter.

Robson.—On November 16, at the R.A.F. Hospital, Nocton Hall, to Brienne (*née* Lockyer), wife of Flt. Lt. R. H. Robson—a son.

Sanderson.—On November 13, at B.M.H. Nicosia, Cyprus, to Patricia, wife of Flt. Lt. C. Sanderson—a daughter.

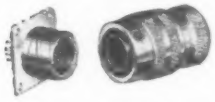
ACCESSIBILITY.—A Simon Hydraulic Platform manufactured by Simon Engineering (Midlands) Ltd., Dudley, being used to service an R.A.F. Valiant B.1.

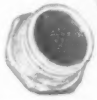


WHEN THERE CAN BE NO COMPROMISE WITH RELIABILITY . . .

. . . When maximum performance under the most exacting conditions is vital, Amphenol Connectors play the part for which they have been designed with complete dependability. More than 25 years' experience in this field plus rigid test requirements far beyond likely operating conditions help to ensure their sturdy reliability.

For example, Amphenol MinniE miniature multi-contact connectors are tested for altitude-moisture resistance by submersion in salt-water, and altitude cycling to 80,000 feet, to 65,000 feet and then returned to room ambient pressure.





Amphenol "MinniE" Connector

Quick disconnect, multi-contact, miniature bayonet lock types. Available as Plugs, Cable and Panel Receptacles and Single Hole mounting Receptacles in four constructions, five shell sizes and seventeen insert arrangements.

Amphenol "165 Series" Connector

Designed especially for use with the ARC52 equipment installed in the Vickers-Armstrongs "Scimitar", the English Electric "Lightning" and other military aircraft. Variants of this 42-contact connector are available to meet different requirements. Another new Amphenol development are the "Stub-E" Connectors, fulfilling environmental resistance requirements in aircraft and guided missiles.

We can also supply miniature co-axial connectors, co-axial changeover switches (hand or relay operated) and micro-potentiometers manufactured by our Industrial Products Danbury-Knudsen and Borg Divisions.

We will be pleased to quote for complete cable assemblies, using Amphenol connectors including "potted" versions if desired.

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IEC2 is a new publication, detailing and profusely illustrating a wide range of Amphenol connectors, with reference sheets for contact arrangements and insert specifications. Write for your copy now.

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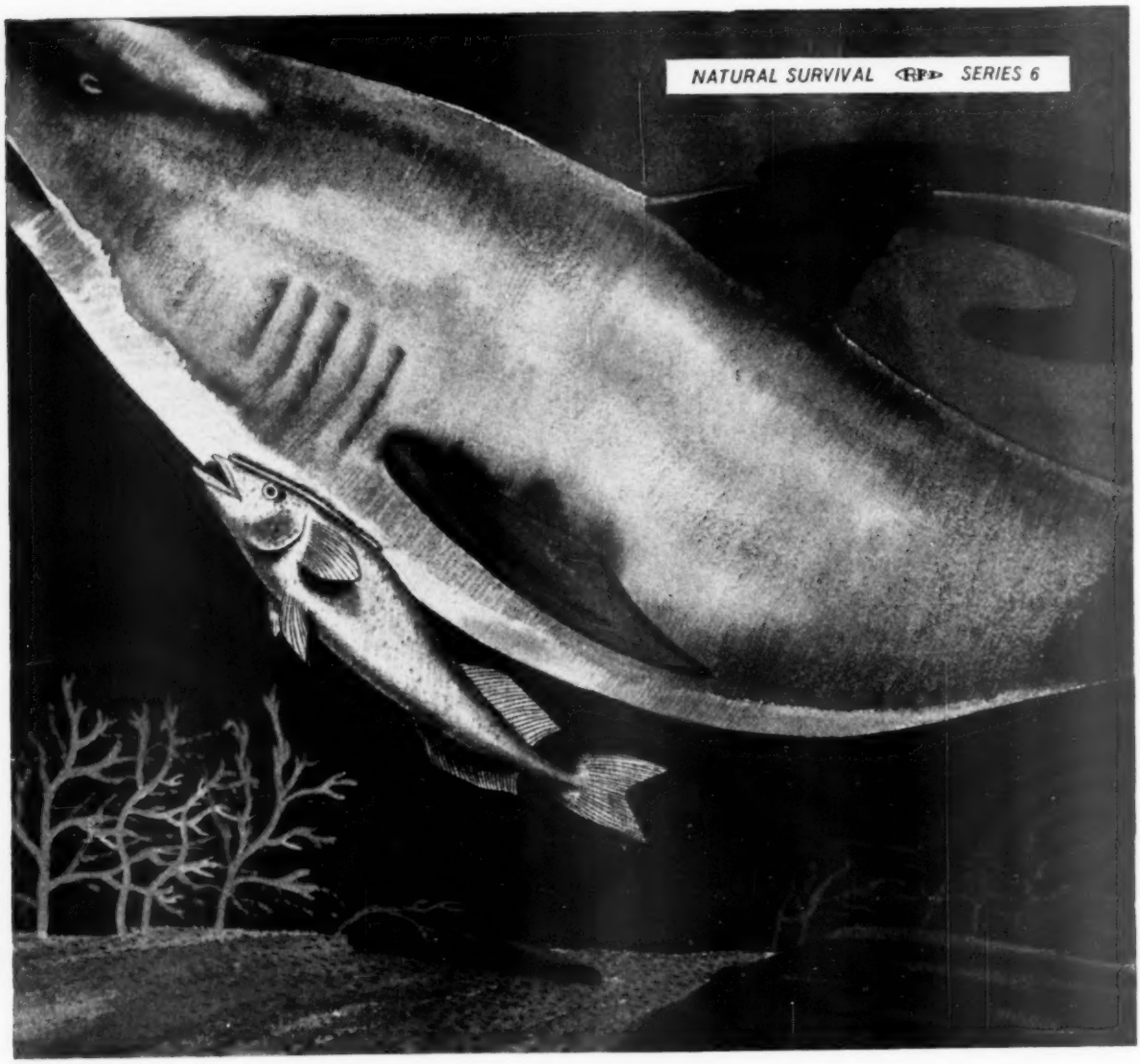

Remora IS A NATURAL HITCH-HIKER

Without doubt the Remora is rarely a welcome travelling companion; never asking for a lift but simply looking out for convenient conveyance and sticking to it! Being a particularly hungry fish, nature has gone to unusual lengths to permit long distance travelling in search of food supplies. Known as the sucking-fish, *Remora remora* arranged that its back fin should be converted into a sucker, with which it attaches itself to sharks, whales–even ships–thus ensuring its survival by quickly travelling from one feeding ground to another.

Sometimes the Remora, which is about two feet long, will travel inside the mouth or gill cavity of large swordfish or sunfish where it not only enjoys protection from attack but also a free meal whenever its host feeds. Even if it is snapped up by a shark or whale it can fasten itself to the roof of the mouth–travel first-class-diner–and escape when convenient.

In a somewhat different manner survival at sea is R.F.D.'s foremost job in life. On the quality and efficiency of R.F.D. equipment depend the safety of passengers and crew of aircraft operated by major airlines of the world.

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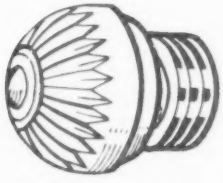
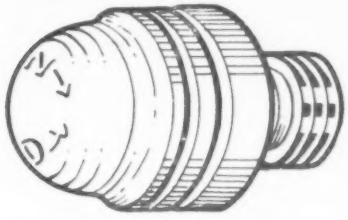
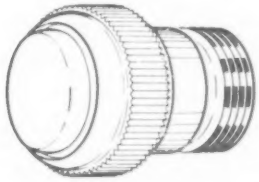
3 ALTERNATIVE CAPS



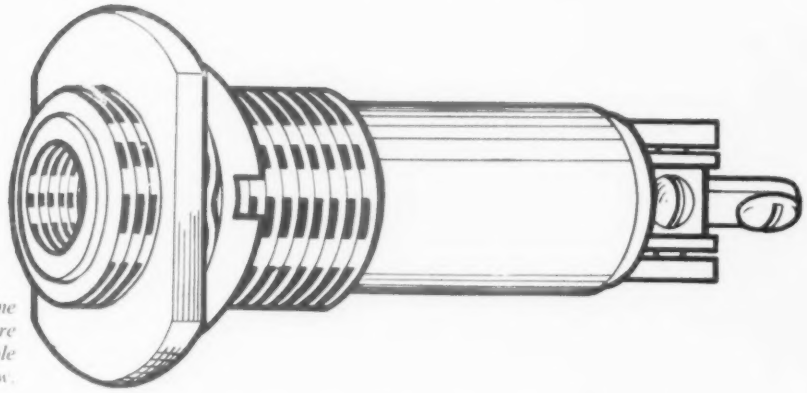
Transparent Indicator Cap in Polystyrene or Glass with surface facets to ensure visibility from all angles. Colours available Red, Green, Amber, Clear, Blue, Yellow.



Dimmer Cap in metal and glass with metal rotary shutter. Built-in stops restrict rotation between fully shuttered and open positions. Colours available, Red, Green, Amber, Clear, Blue.



Flat top Indicator in Polystyrene with engraving to order. Colours available Translucent Red, Amber, Green, White and Transparent Blue.



This extremely compact Illuminated Press Switch employs the now famous Atlas Midget Panel Lamp and by the incorporation of the 5-terminal arrangement, is capable of 34 circuit variations. As shown, three different caps can be employed for indicating or dimming purposes and each is available in a wide range of colours. The units are vibration proof, maintaining predetermined contact pressures and can be supplied for 6, 12 and 28 Volt circuits. Screw terminal or solder tag versions are available to order.

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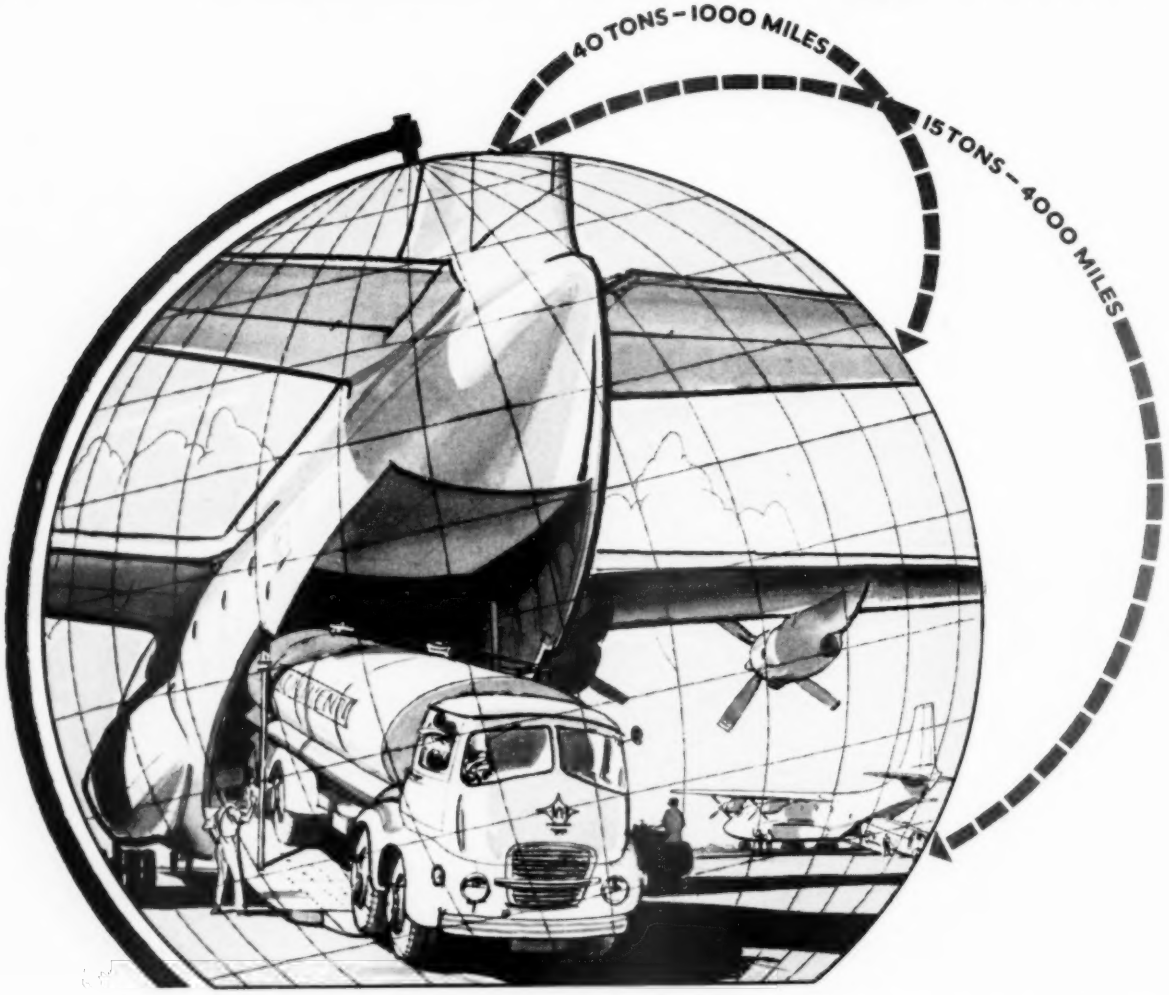

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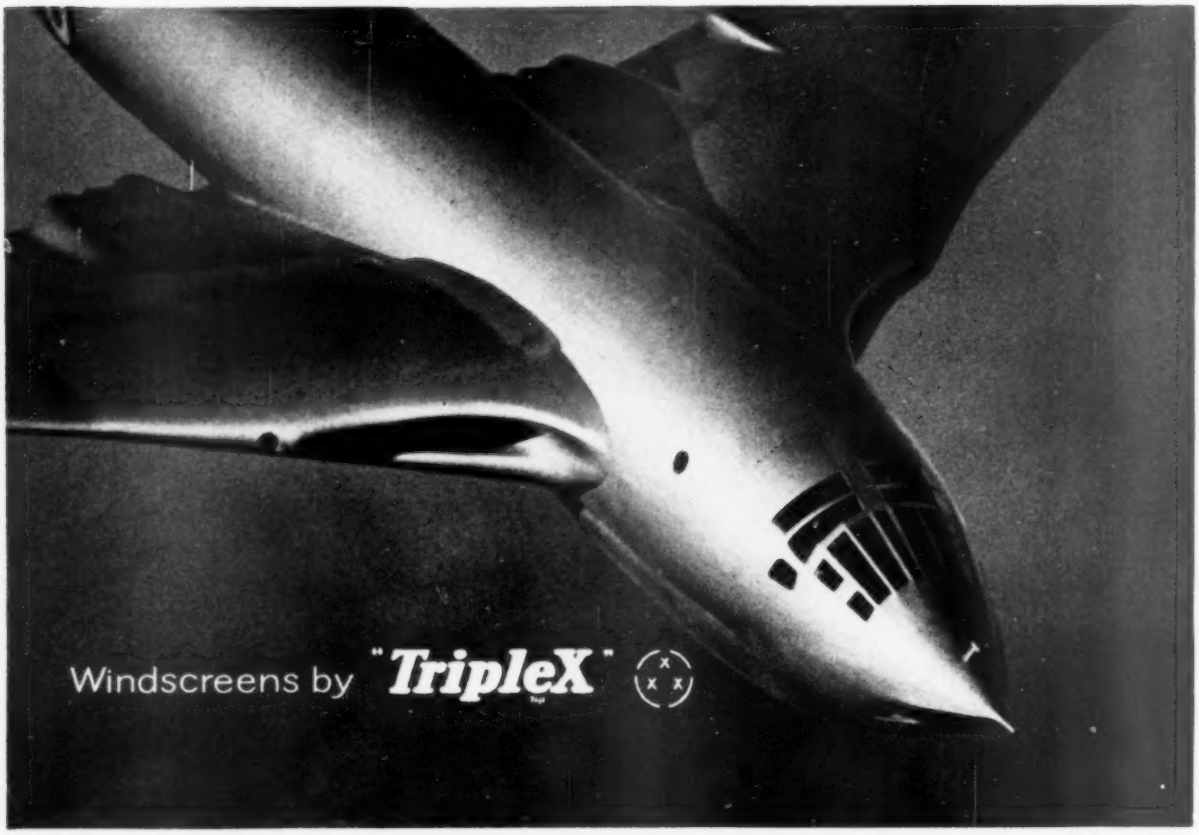

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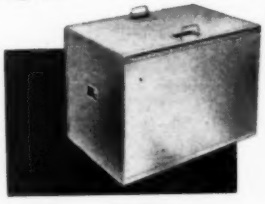

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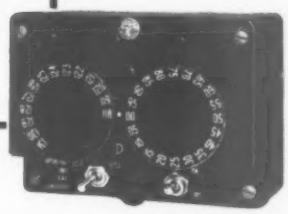

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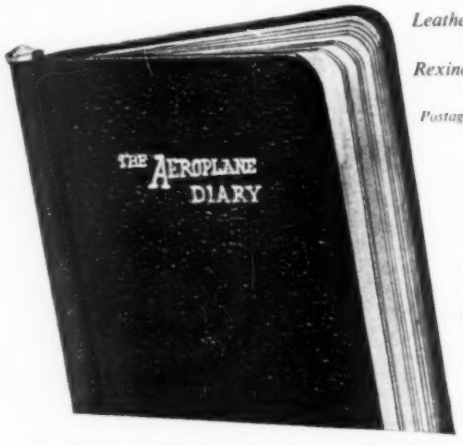

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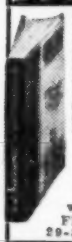

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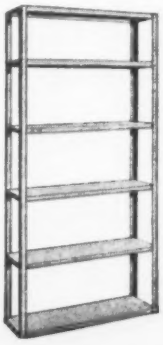

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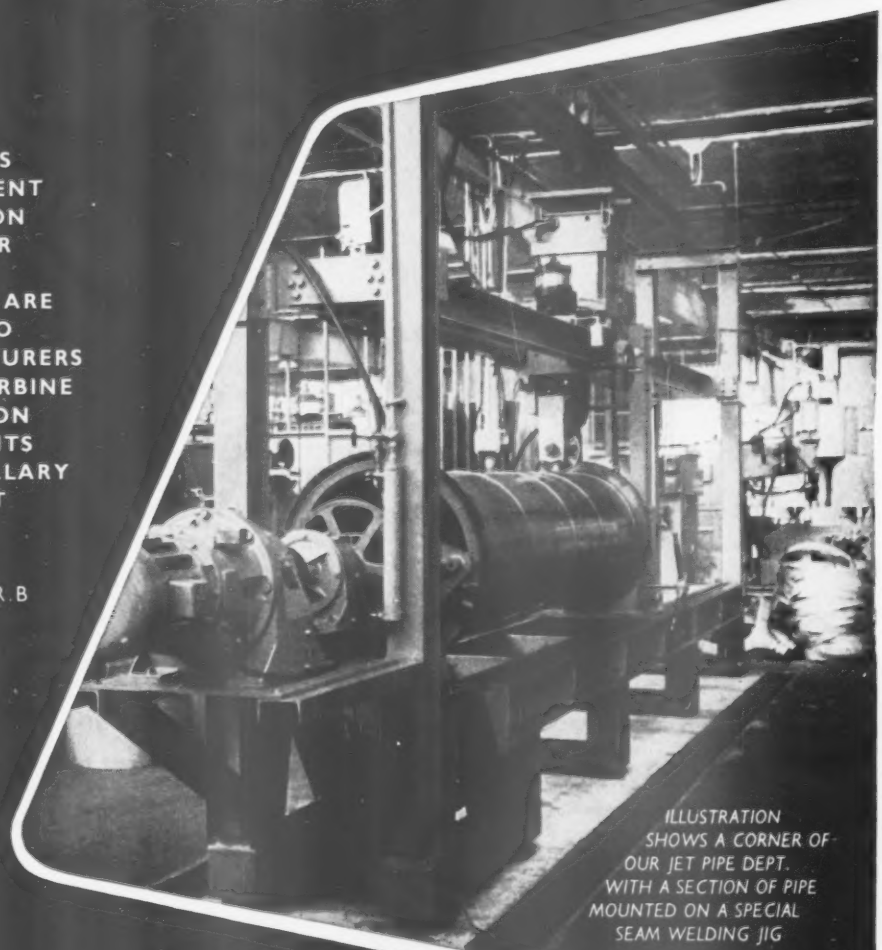

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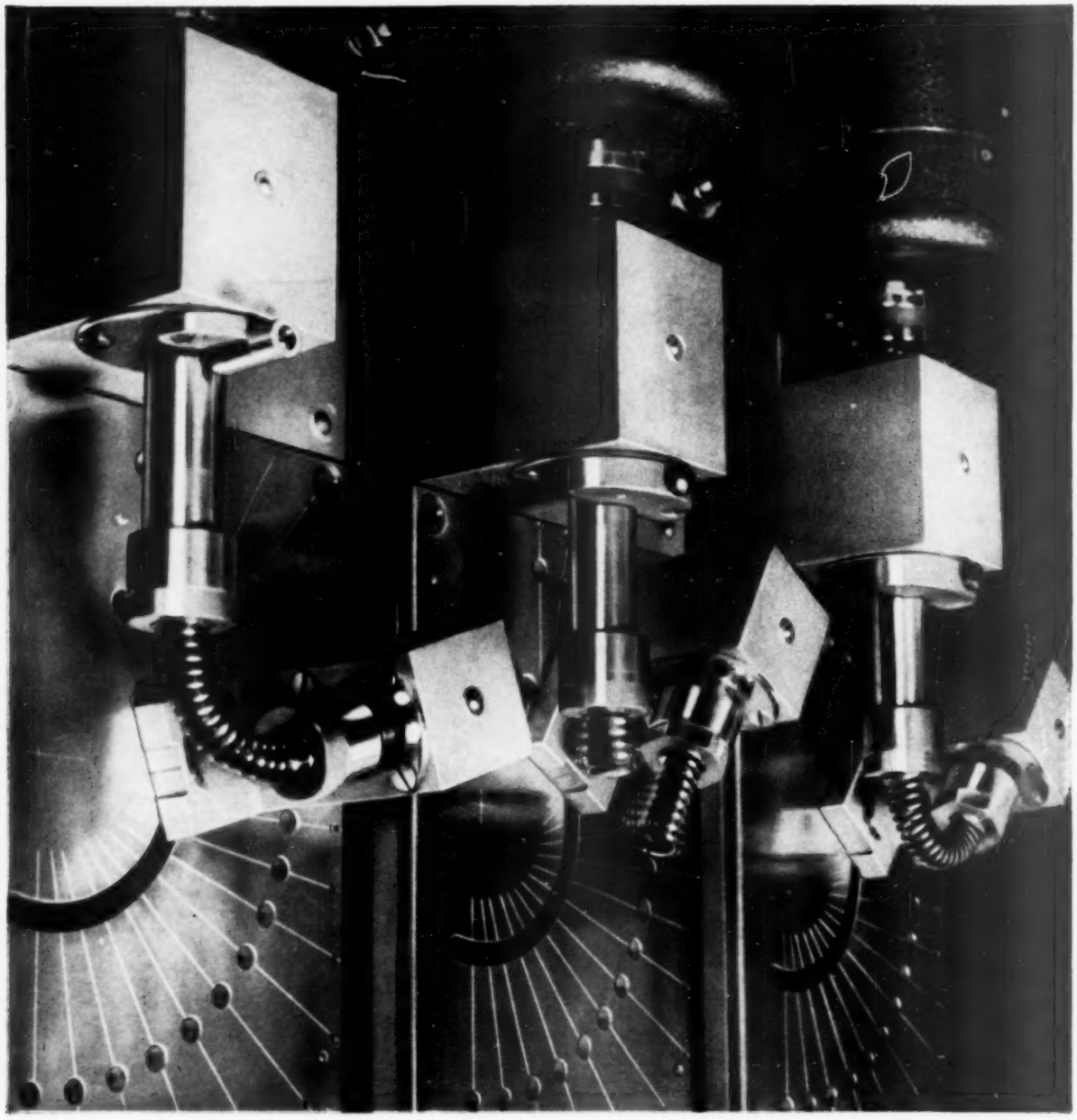

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